PB-230 500

POLLUTION OF LAKE MICHIGAN AND ITS TRIBUTARY BASIN. PROCEEDINGS OF CONFERENCE, SESSION (3RD) HELD AT CHICAGO, ILLINOIS, ON SEPTEMBER 28-OCTOBER 2, 1970. VOLUME 3

Federal Water Quality Administration
Washington, D.C.

2 October 1970

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 230 500 ✓

PROCEEDINGS

THIRD SESSION
RECONVENED IN
WORKSHOP SESSIONS

September 28, 29, 30,

October 1, 2, 1970.

Chicago, Illinois

Vol. 3,

CONFERENCE

Pollution of Lake Michigan and Its Tributary Basin

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

U.S. DEPARTMENT OF THE INTERIOR . . . FEDERAL WATER QUALITY ADMINISTRATION

WORKSHOP SESSION FOR THE THIRD SESSION OF THE CONFERENCE IN THE MATTER OF POLLUTION OF LAKE MICHIGAN AND ITS TRIBUTARY BASIN IN THE STATES OF WISCONSIN, ILLINOIS, INDIANA, AND MICHIGAN - - - VOLUME III

Bal Tabarin Room
Sherman House
Chicago, Illinois
September 30, 1970

CONTENTS

	Page
Joseph A. Pelletier	967
Robert M. Kopper	987
Fabian C. Polcyn	997
David H. Williams, Jr.	1015
John C. Ayers	1042
O. D. Butler	1093
Wesley O. Pipes	1130
Evan W. James	1161
Sol Burstein	1186
Yates M. Barber	1225
John G. Carr	1230
Peter J. Colby	1261
Thomas A. Edsall	1288
Richard Callaway	1330
John T. Graikoski (Read by Kenneth Roberts.)	1358
Charles Powers	1367

- - -

Workshop Session for the Third Session of the Conference in the Matter of Pollution of Lake Michigan and Its Tributary Basin, in the States of Wisconsin, Illinois, Indiana, and Michigan, held in the Bal Tabarin Room of the Sherman House, Chicago, Illinois, on Wednesday, September 30, 1970, at 9:00 a.m.

- - -

PRESIDING:

MURRAY STEIN, Assistant Commissioner for Enforcement and Standards Compliance, Federal Water Quality Administration, U.S. Department of the Interior, Washington, D.C.

- - -

CONFEREES:

BLUCHER A. POOLE, Technical Secretary, Stream Pollution Control Board, Indiana State Board of Health, Indianapolis, Indiana.

PERRY E. MILLER, Assistant Director, Stream Pollution Control Board, Indiana State Board of Health, Indianapolis, Indiana.

RALPH W. PURDY, Executive Secretary, Michigan Water Resources Commission, Lansing, Michigan.

CONFEREES (Continued):

FRANCIS T. MAYO, Regional Director, Federal Water Quality Administration, U.S. Department of Interior, Chicago, Illinois.

ALTERNATE CONFEREES:

CARL T. BLOMGREN, Environmental Control Engineer, Illinois Environmental Protection Association, Springfield, Illinois.

RICHARD S. NELLE, State Sanitary Engineer, Illinois Environmental Protection Association, Springfield, Illinois.

DAVID P. CURRIE, Chairman, Illinois Pollution Control Board, Chicago, Illinois.

CARLOS FETTEROLF, Supervisor, Water Quality Standards Appraisal, Michigan Water Resources Commission, Lansing, Michigan.

DONALD J. MACKIE, Assistant Secretary, Division of Environmental Protection, Wisconsin Department of Natural Resources, Madison, Wisconsin.

ROBERT P. HARTLEY, Director, Office of Enforcement and Cooperative Programs, Federal Water Quality Administration, U.S. Department of Interior, Chicago, Illinois.

PARTICIPANTS:

Joseph A. Pelletier, Vice President, Northern Indiana Public Service Company, Hammond, Indiana.

Michael Sheldrick, McGraw-Hill publications.

Byron O. Lee, Jr., Assistant to the President, Commonwealth Edison Company, Chicago, Illinois.

G. Fred Lee, Professor of Water Chemistry, University of Wisconsin, Madison, Wisconsin.

A. Joseph Dowd, Assistant General Counsel, American Electric Power Service Corporation, Two Broadway, New York, New York.

Robert M. Kopper, Executive Vice President, Indiana and Michigan Electric Company, Fort Wayne, Indiana.

Fabian C. Polcyn, Research Engineer, University of Michigan, Ann Arbor, Michigan.

David H. Williams, Jr., Assistant Vice President and Chief Mechanical Engineer, American Electric Power Service Corporation, New York, New York.

Jacob Dumelle, Member, Illinois Pollution Control Board, Chicago, Illinois.

John C. Ayers, Professor of Oceanography, University of Michigan, Ann Arbor, Michigan.

Bruce A. Tichenor, Chief, Hydrographic Branch, National Thermal Pollution Research Program, Pacific Northwest Water Laboratory, FWQA, U.S. Department of the Interior, Corvallis, Oregon.

PARTICIPANTS (Continued):

Yates M. Barber, Jr., Staff Assistant to the Assistant Director of Research, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, Annandale, Virginia.

O. D. Butler, Assistant Vice President, Commonwealth Edison Company, Chicago, Illinois.

Wesley O. Pipes, Professor of Civil Engineering, Northwestern University, Evanston, Illinois.

Evan W. James, Vice President, Power Generation and Engineering, Wisconsin Public Service Corporation, Green Bay, Wisconsin.

Sol Burstein, Senior Vice President, Wisconsin Electric Power Company, Milwaukee, Wisconsin.

O. K. Petersen, Senior Attorney, Consumers Power Company, 212 W. Michigan Avenue, Jackson, Michigan.

John F. Carr, Chief, Environmental Research Program, Fish and Wildlife Service, U.S. Department of the Interior, Ann Arbor, Michigan.

Charles A. Bane, Attorney, of the firm of Isham, Lincoln and Beale, One First National Plaza, Chicago, Illinois.

Mary Alice McWhinnie, Professor, DePaul University, Chicago, Illinois.

Steven E. Keane, Attorney, Wisconsin Public Service Corporation, Milwaukee, Wisconsin.

Jack L. Hipke, Environmental Chemist, Wisconsin

PARTICIPANTS (Continued):

Power and Light Company, Madison, Wisconsin.

Kenneth R. Roberts, Resource Management Officer, Bureau of Commercial Fisheries, U.S. Department of the Interior, Arlington, Virginia.

John R. Brough, Director, Air and Water Control, Inland Steel Company, East Chicago, Indiana.

Peter J. Colby, Aquatic Biologist, Fish and Wildlife Service, U.S. Department of the Interior, Ann Arbor, Michigan.

Kenneth Lehner, Superintendent of Chemical Services, Wisconsin Electric Power Company, Milwaukee, Wisconsin.

Thomas A. Edsall, Fishery Biologist, Bureau of Commercial Fisheries, U.S. Department of the Interior, Ann Arbor, Michigan.

Daniel Feldman, Attorney, of the firm of Isham, Lincoln and Beale, One First National Plaza, Chicago, Illinois.

Charles Powers, National Eutrophication Laboratory, FWQA, U.S. Department of the Interior, Corvallis, Oregon.

Richard Callaway, Chief, Physical Oceanography Branch, National Coastal Pollution Research Program, Corvallis Laboratory, FWQA, U.S. Department of the Interior, Corvallis, Oregon.

PARTICIPANTS (Continued):

John T. Graikoski, Microbiologist, Bureau of Commercial Fisheries, U.S. Department of the Interior, Ann Arbor, Michigan. (Read by Kenneth R. Roberts.)

START-965

Murray Stein

PROCEEDINGS

- - -

MR. STEIN: Let's reconvene.

Let me outline some procedural problems we have here. One, because we are running a little longer than we expected, we are going to have to make some adjustments in agenda in relation to the Commonwealth Edison Corporation.

Will Mr. Petersen please come up?

This is the next point I wanted to talk about. As you know, the acoustics in this room are fiendish, particularly for the reporter.

Mrs. Hall has put herself in the spot where she thinks she can hear best, which is over here on my left. This is going to place an obligation on the people in the panel on my right, and I would ask those to speak very, very clearly, and identify yourself by name because she can't really see you there.

Now, again, we also have a religious situation, where some people have to get out of here by sundown. If any of these people have a problem of that kind and have to get on, to get out, I wish they would let Mrs. Piere know, and we will make arrangements so that will be done.

With that, may we have Mr. Petersen?

MR. PETERSEN: Due to the passage of time and interruptions, Mr. Bane of Commonwealth Edison has consented to let two other companies make their presentations before Commonwealth Edison continues with its presentation.

In both cases, it would be advisable to allow the questioning from the panel and from the floor while the witnesses are here.

MR. STEIN: I think if this is agreeable to all -- because of the complications we had, and the audience looks as if it expected it, it has gotten a little smaller -- I think it might be helpful if we just followed that procedure with all of the witnesses from here on out. I think it will move faster.

Is that agreeable? In addition to the panel we will have public participation.

All right.

MR. PETERSEN: Mr. Joseph A. Pelletier, Vice President in charge of Engineering and Electric Operations for Northern Indiana Public Service Company, NIPSCO, will give the statement for that company.

STATEMENT OF JOSEPH A. PELLETIER, VICE PRESIDENT, NORTHERN INDIANA PUBLIC SERVICE COMPANY, HAMMOND INDIANA

MR. PELLETIER: Mr. Chairman, conferees, ladies and gentlemen, my name is Joseph A. Pelletier. I am employed by Northern Indiana Public Service Company as its Vice President in charge of Engineering and Electric Operations. I thank you for the opportunity to appear before this third session of the Federal Conference on Lake Michigan and its Tributary Basin. In my statement I will refer to Northern Indiana Public Service Company as "NIPSCO."

NIPSCO is a combination utility engaged in supplying electrical energy and natural gas to the public in thirty counties in the northern part of Indiana. NIPSCO's principal office is located at 5265 Hohman Avenue, Hammond, Indiana 46320. NIPSCO serves an area of 12,000 square miles, which has an estimated population of 2 million. The company serves approximately 311,000 electric customers and 421,000 gas customers. NIPSCO presently has three generating plants located on Lake Michigan. These plants are the Mitchell Generating Station, located at the western edge of Gary, Indiana; the Bailly Generating Station, located in Porter County, Indiana; and the Michigan City Station, located at Michigan City, LaPorte County, Indiana.

Additional electrical generating units are committed for the Michigan City Generating Station and the Bailly Generating Station.

NIPSCO's experience has been that the electrical demand in its territory has approximately doubled every 10 years. Geographically speaking, 70 to 75 percent of the company's electrical demand has come from LaPorte, Porter and Lake County areas, which are the counties in which our present generating plants are located. NIPSCO understands the environmental and ecological problems facing the country and is keenly interested in their solution, and has committed large sums of money in existing and proposed facilities to provide improved environmental controls.

Additionally, the company has participated in studies of Lake Michigan in an effort to determine the validity or lack of validity of charges concerning the effect upon the lake of cooling water discharges by generating plants.

NIPSCO has operated generating plants on Lake Michigan for approximately 40 years and during the course of this operation it has been observed:

1) The extent of cooling water discharges into the lake has been very local. Observations recorded by photographs taken of the lake in wintertime show that shore ice is undisturbed except in the immediate area of the discharge plume.

2) Fish apparently find the temperature of the discharge to their liking, as there has been a concentration of fishermen at the discharge plume on many occasions during the 40-year history of NIPSCO's operation on the lake.

3) Since 1967, NIPSCO has been conducting water quality tests at Mitchell Generating Station, Gary, Indiana, and Bailly Generating Station in Porter County, Indiana, at the request of the Indiana Stream Pollution Board. These tests have shown no change in the water quality from warming.

4) During the 40 years of NIPSCO's operation on Lake Michigan no adverse results have been observed due to our cooling water discharges into the lake.

The company has also reviewed and studied infrared slides taken of our facilities from the air by Willow Run Laboratories of the University of Michigan. We are informed that these slides will be made available to the conferees by Willow Run Laboratories at this conference.

The conclusion that we reach from these slides is that the effect of the discharge plume is very local, consistent with the observations as to shore ice heretofore mentioned and temperature profile studies. The temperature of the shore water is relatively uniform along the shore outside of the immediate area of the discharge plume.

The company's facilities have been examined as part of a study of Lake Michigan conducted by Dr. John C. Ayers of the University of Michigan. The results and conclusions of Dr. Ayers' study have presented or will be presented to the conferees at this workshop.

In substance, it is our company's position that the thermal effect of electrical generating stations upon the 14.3 million acres of Lake Michigan is insignificant. Much of the year the lake is unusable for bathers because of the extremely cold temperature of the lake. Electrical generating plants cannot change this natural condition found in the lake. Further, we have closely followed scientific studies of cooling water discharges on the lake and we have not seen any evidence in those studies of adverse effects due to generation plants.

J. A. Pelletier

On the other hand, the lake contributes substantially as a natural resource to the production of power in the States of Illinois, Wisconsin, Michigan, and Indiana. The citizens of these States have an interest in the supply of adequate, reliable and economical power. This interest is also part of the public interest in its larger context and must be considered along with the environmental interests. Standards should not be established which threaten the adequacy and reliability or unnecessarily increase the cost of electricity to the consumers of Illinois, Wisconsin, Michigan and Indiana.

It is in the nature of the electrical industry that commitments for construction and actual construction must precede the demand for energy. Commitments and construction starts have been made by the industry to meet the demands of the next decade. A good deal of this construction necessary to supply electricity in the next 10 years is being obstructed and delayed by arguments based upon what it is anticipated the lake thermal additions may be by the year 2000. The construction necessary to meet the requirements in the next 10 years should not be delayed by these arguments. Research, studies and monitoring programs now under way and proposed can reliably establish criteria, if necessary for future regulation, long before the year 2000. A standstill at this point in time based upon concern for a greatly increased number of plants by the year 2000 will severely affect the residents of the Midwest in the 1970's.

In 1967, the State of Indiana adopted thermal standards for Lake Michigan. These standards were submitted to the United States Department of Interior and were approved by that Department. NIPSCO operates within the standards as adopted by the State of Indiana and as approved by the Department of Interior. Subsequently, we are informed, the Department of Interior notified the State of Indiana that the standards so adopted should be reconsidered. We are unaware of the basis upon which such a decision was made. Likewise, we are unaware of any scientific studies or data in existence that would warrant the change in the position of the Department of Interior.

We are further informed that the Department of Interior proposes that no heat discharges will be permitted in excess of 1 degree F. rise over ambient at the point of discharge and that there will be no mixing zones. We are unaware of any studies that have been made which would support this standard. The two papers recently released by the Department of Interior on the previously-announced-1-degree proposal do not contain any significant information which would warrant a change from the presently-adopted standards of the conferee States. The effect of the Department of Interior policy would be to prohibit the operation of NIPSCO's three existing generating plants and the construction of any new plants necessary to meet the electrical demands of our area.

We earnestly suggest that Lake Michigan is a valuable natural resource that is important to the producers and consumers of electrical energy as well as others here represented and that the thermal effect of generating plants is local and insignificant. We further urge the conferees to conclude that the existing Indiana standards are adequate and presently need no revision, and that the Department of Interior proposal is unnecessarily restrictive and detrimental to the electrical power needs of the area.

Thank you.

MR. STEIN: Thank you. Are there any comments or questions?

MR. MAYO: I have a question. In essentially the last sentence on your page 3, you say the effect of the Department of Interior policy would be to prohibit the operation of NIPSCO's three existing generating plants.

What brought you to that conclusion?

MR. PELLETIER: In looking at the arrangement that would be required for attempting to meet the 1-degree arrangement, it would be necessary to make complete revisions with respect to the plant facilities, not knowing what the timetables could be with reference to installation of these devices to provide for cooling other than the once-through cooling. We would have difficulty and probably not be able to utilize -- depending on what the timetable would be using this facility.

If a sufficient timetable were given, its revisions could be made and it would not be necessary to rule out the plant operation.

MR. MAYO: I think perhaps you are generally familiar with the procedures in this matter involving water quality standards. Where once the standard is set precisely and its non-conforming discharges identified, some reasonable period of time is given in which to take the remedial action. So, I think it is inappropriate for you to state flat out that the adoption of the recommended Department of Interior position would in fact prohibit the operations of the existing plants. I really think that statement is erroneous.

MR. PELLETIER: Mr. Mayo, in dealing with all of the environmental areas I think a number of companies -- especially the steel companies -- run into problems of not being able to make some of the schedules. We are faced with this in the utility industry, based on some of the deadlines given with respect to air quality and so on.

Based on the equipment that may be available, being able to take a unit out of service and so on -- and then comes a Court action with respect to a timetable -- there is a question of whether you shut the plant down or continue.

MR. MAYO: Well, I think if we look at the history of the enforcement conference, in fact on the steel industry in Lake Michigan, I think we will find without any question that there has not been any threat of shutdown. There hasn't been any significant impact on production and yet the steel companies have moved ahead with some reasonable speed in meeting the requirements of the conference. So I would hope that as far as the electric generating industry is concerned and the public generally, that there would be an appreciation of the fact that we would seek the same solution, to the extent that current waste heat discharges might later be determined to be in nonconformance with a standard adopted by the conferees and by the States.

MR. STEIN: Thank you. Are there any other comments or questions?

Mr. Pelletier, in the interest of communication, let me try something again because I know if you say something over and over again, even though it may in fact be somewhat larger than the truth, you tend to believe it. It impedes working out a solution to the problem.

One, we have pointed out the Interior Department does not have a policy yet on temperature in the Great Lakes or in Lake Michigan. That is why we are here today.

The Department of the Interior has not made a proposal. As we always have at these enforcement conferences, we have a report by an investigatory staff within the Department of the Interior who have come up with certain conclusions and recommendations for consideration by the conferees. I just ask that we consider these. At the beginning, I said we are trying and I hope we can work out with the power industry a position and adopt a policy of the Department of the Interior, as well as the other States, that will be fully compatible with the requirements for operation of the power industry. We do this all the time with other industries.

As I said many, many times before, anyone can clean up pollution by shutting down a plant -- whatever it is -- or putting a padlock on the city hall. That is no challenge. The challenge is to keep you going, to keep you competitive, and having you serve the needs of the people and yet to protect the environment. And I think if we start with that, we are going to be in a lot better position to work out an agreement. I ask you again to consider the record that we have not adopted a policy nor has the Department of Interior put forward a position yet.

MR. PELLETIER: It was my understanding that this was the position of the Department of Interior, that the 1-degree position or proposal -- I know that it isn't the rule or the law, and that we have to go through the normal procedure, but I think the general understanding of the public and what you see in the papers, and so on, is that this is a proposal or a movement of the Department of the Interior.

MR. STEIN: I understand that. That is why I said this again. I know I said this at the beginning of the conference, and whatever your impression is -- by the way, I have read the newspaper reports. I think they are accurate. They have reflected this when we reported it to the papers. They have reported this. But -- I know that may have been a judgment, as reflected in several papers presented here, but I think this is an important enough point, and I think I am speaking officially for the Department because we have been over this point or these points or these -- what we consider -- misunderstandings many, many times.

The Secretary of the Interior has indicated that he makes the policy for the Department, and he hasn't spoken on this yet. I don't think he is going to make his judgment on this until he gets the recommendations of the conferees sitting here. So we have no policy. We have made no proposal from the Department because we never do at one of these conferences. If we made this proposal we wouldn't need this conference here.

We have an investigatory group. The conferees are going to come up with recommendations, and I will take those recommendations back and have them sent to the Secretary of Interior for his judgment. This is the procedure we are in now, and I think if we can have a clear understanding of that, please do.

Again, I wish you could realize that some of the questions and comments that we are raising here are to bring points into sharp focus because we have no judgment or prejudgment of this matter.

MR. MAYO: Mr. Chairman, you mentioned cleaning up pollution by padlocking city hall. We don't have anyone on our list yet on Lake Michigan. Have we missed something?

MR. STEIN: We had several on our list.

Do we have any others?

Thank you very much.

MR. PELLETIER: Thank you, sir.

MR. PETERSEN: With your indulgence, we would like to make another change. Commonwealth Edison Company has three speakers who we would like to offer for public questioning, and at this time Consumers Power Company would like to offer D. H. Brandt and Dr. Reynolds for questioning hopefully to catch up as much as possible before the presentations.

MR. STEIN: Are there any questions from the audience of either Mr. Pelletier or the others, at the present time?

If not, would you continue?

MR. PETERSEN: The two witnesses that Consumers Power Company has to offer for questions are D. H. Brandt and J. Z. Reynolds.

MR. STEIN: I see no request for questioning, so let's continue with the presentation.

MR. BANE: Thank you very much.

MR. STEIN: Right.

(Discussion off the record.)

MR. SHELDRICK: My name is Michael Sheldrick. I am with McGraw-Hill Publications. I have a total of four questions. I will try to make them as brief as possible.

MR. STEIN: Let's ask one at a time.

MR. SHELDRICK: One at a time?

MR. STEIN: Yes.

MR. SHELDRICK: First of all, it appears to me that the biological and ecological studies that were presented here by various witnesses for Commonwealth Edison all appeared first about April of 1968. We also heard that the site was purchased some 15 years ago, and with my knowledge of the way nuclear plants are built, the company began at least 5 or 6 years ago, had made a decision on the nature of the plant and what it would look like. Why did the biological studies only begin in 1968, and if they didn't before, could you describe all of the ecological and biological studies that have been conducted both at Zion and in general for Lake Michigan?

MR. STEIN: Would you identify yourself?

MR. BANE: Byron Lee, who previously testified, will respond to this question.

MR. LEE: Well, you are perfectly correct in that we have owned the site for 15 years. It has been our choice not to build at that site for this period of time primarily because we felt that this was not a good site for a fossil-fuel -- which in our terms means coal -- fired plant. Because of its location we felt that this was a plant that was best suited for nuclear power. As a consequence, the decision to build the nuclear powerplant was not made until it really -- nuclear power had proved itself to be the right direction to go.

This decision was made about 1967 to build and design units and, as you pointed out, the studies started shortly thereafter. We think that this is a fairly reasonable time schedule to take with the operation of the plants not starting until 1972 and 1973.

There was another part of the question, and I am afraid --

MR. SHELDRICK: Yes. I was just wondering -- I can't pinpoint it exactly, but I think you did say that a number of other places have been studied over a considerable length of time, particularly Waukegan. Could you describe the kind of ecological studies you have been doing for whatever period you have been doing them?

MR. LEE: Well, basically, the other studies that we have been doing are, of course, at Waukegan. There have been others. The study at Waukegan -- the first study we have talked about -- is 1968. We have looked at the basic outflow, and the effects of the outflow in general terms at Waukegan. I would say the other location where we have run studies of some depth have been at our Dresden nuclear power station, and these date back, of course, to the start of that plant in the late 1950's.

MR. SHELDRICK: This second one is pretty much directed at scientists, although if you care to answer, that would be fine, too.

You have hinted -- and other people have -- that if there is evidence of damage to the lake, even though you submit at the same time that there won't be damage, you will then take remedial action.

I would like to ask the scientists if they really think there is enough data to draw a baseline from which we can later determine if there is any deterioration of the water quality in the lake as a result of the discharges, and if not what kind of data should be gotten, in what sort of period -- 1 year, 2 years, 5 years, etc.?

MR. LEE: Well, I would answer in general I think that the study plan that we have submitted, I believe, to the conferees, indicates the scope of the studies that we intend to run. It goes into great detail on the information to be gathered, and the duration, of course -- these studies will continue through this year and we will keep updating them, depending on the results of what we find, and they will continue through the start of the plant and then will continue after the plant is in service for a long enough time to verify what we are saying.

Now, I don't know if Dr. Lee would like maybe to add anything to that or not.

DR. G. FRED LEE: Yes, I would support what has been said here with regard to these studies. I think that we have on the books now a reasonably good plan to determine, I think, any significant changes in the characteristics of the area. We could determine the baselines now and the changes that may occur after the plant goes into operation.

MR. SHELDRICK: All right. I have talked to many people in the course of my activities. One of the things I have found, among other scientists some of whom work for FWQA -- they seem to say that the research results of Commonwealth Edison and perhaps other people are private research results. I am not -- I haven't finished with my question yet. If indeed these are studies that you are funding will you make them available to the qualified scientific researchers and the general public, and at what point — as the results come in, and when? I would like to know what is your general position on releasing research that you fund.

MR. BYRON O. LEE: Well, I think we have stated several times that the results of these reports will be available to the various governmental agencies and other people. We have tried to cooperate with all organizations.

In my statement I indicated that the Argonne National Laboratory is really acting as a coordinator on the studies being conducted at Waukegan and Zion between Argonne, the Metropolitan Sanitary District and EPRO and ourselves, and anybody else who would care to go into this study plan.

MR. SHELDRICK: One final one: Would you be willing to put up a performance bond at Zion which you would forfeit in the event that there is deterioration of water quality, say, 5 years, 10 years, or whatever period, as sort of an act of good faith on your part?

MR. BYRON O. LEE: I defer to the legal counsel here.

MR. BANE: I think that is a legal question. I haven't heard anything, and I don't know of anything that impugns the good faith of Commonwealth Edison. We are always financially responsible so I don't see any need for a bond.

MR. STEIN: By the way, are you and Dr. Lee brothers?

MR. BYRON O. LEE: No, sir.

MR. STEIN: Related?

MR. BYRON O. LEE: Never met before until several months ago.

MR. STEIN: I was wondering because you look a little bit alike.

MR. BYRON O. LEE: No.

MR. STEIN: Thank you.

MR. PETERSEN: A. Joseph Dowd, the counsel for Indiana and Michigan Electric Company, will be in charge of their presentation.

MR. DOWD: Mr. Chairman and conferees, ladies and gentlemen. My name is A. Joseph Dowd. I am Assistant General Counsel, American Electric Power Service Corporation, acting as counsel for Indiana-Michigan Electric Company at this conference.

Indiana-Michigan Electric Company's presentation this morning consists of four statements: The first by Mr. Robert M. Kopper, Executive Vice-President and Chief Operating Officer of Indiana-Michigan. The second by Mr.

Fabian C. Polcyn, Research Engineer of Willow Run Laboratories. The third by Mr. D. H. Williams, Assistant Vice-President and Chief Mechanical Engineer of the American Electric Power Service Corporation. And the fourth by Dr. John C. Ayers of the University of Michigan.

I should note that the professional qualifications of our three technical expert witnesses, Mr. Polcyn, Mr. Williams and Dr. Ayers, are attached to their prepared statements, and we request that they be incorporated in the record.

Now, it is also my understanding that all questions of these witnesses will be asked by the conferees and by the members of the public at the conclusion of their respective statements, is that correct?

MR. STEIN: That is correct.

I think we will move faster that way.

MR. DOWD: Fine.

Mr. Kopper.

STATEMENT OF ROBERT M. KOPPER, EXECUTIVE VICE-PRESIDENT, INDIANA AND MICHIGAN ELECTRIC COMPANY, FORT WAYNE, INDIANA

MR. KOPPER: Mr. Chairman, members of the conference, ladies and gentlemen. I am Robert M. Kopper, Executive Vice-President of the Indiana and Michigan Electric Company, and its chief operating officer. I appreciate this opportunity to present my company's position with respect to the effect of warm water discharges into Lake Michigan.

The Indiana and Michigan Electric Company, which is a part of the American Electric Power System, supplies electric energy to more than 188 communities in the States of Indiana and Michigan. Over 1,600,000 people in our service area are depending upon us for an adequate and reliable electric power supply.

Demands for electric power have been increasing over the Nation at a rate requiring the doubling of electric generating capacity every 10 years. The territory in which we operate in southwestern Michigan and northern Indiana is growing at an even faster rate which requires the doubling of electric generating capacity every 8-1/2 years. As a public utility, we have an obligation under the law to see to it that the necessary generation, transmission and distribution facilities are available in order to meet in a reliable manner this increasing demand for electric energy. A substantial part of the increased demand for electric power will be for municipal and industrial purposes to eliminate discharges to air as well as water that cause pollution.

It was this growing demand for electric power in southwestern Michigan and northern Indiana that dictated the need to build a large powerplant in the area -- a nuclear plant -- since our service area is some distance from the coalfields of West Virginia, Kentucky, and Ohio.

In March of 1969, we received a permit from the Atomic Energy Commission to construct the Donald C. Cook Nuclear Plant on the southeastern shore of Lake Michigan at Bridgman, Michigan. The Cook Plant, which is presently under construction, will consist of two 1,100 megawatt units and will have a capital cost of approximately $400 million, over $100 million of which has already been expended. The plant will utilize the once-through method of condenser cooling. At full load, this will involve the circulation of about 1.5 million gallons of lake water per minute. The company, after public hearing, received the necessary authorization from the Michigan Water Resources Commission to make this use of the lake water subject to the condition that if any injury to the lake should result from the discharge of this cooling water, the company will take whatever corrective action may be necessary to eliminate such injury. The cooling water will be returned to the lake by means of a submerged outlet located approximately 1,200 feet offshore. At maximum plant loading, the temperature of the cooling water across the condensers will be 21 degrees Fahrenheit warmer than at the intake pipe. Also after public hearing, the company received the necessary approval of the Corps of Engineers for the construction of this cooling water system, and such construction is presently under way.

Our decision to utilize the once-through cooling method was arrived at on the basis of extensive and detailed studies showing that warm-water discharges will have no adverse effect upon the lake's ecology. To carry out these studies, we obtained the services of the Great Lakes Research Division of the University of Michigan, and of Dr. John C. Ayers, who will be presenting a statement later today. Frankly, when we initially contacted Dr. Ayers, he advised us of his apprehension over the warm water effects of the existing and proposed powerplants on the lake and indicated that he was considerably disturbed. We agreed to have the Great Lakes Research Division make the studies with the full understanding that their findings would be accepted on the basis of their own independent evaluations. Dr. Ayers' conclusions, which he will present to you later, as well as those of our own technical people, are to the effect that warm water discharges into Lake Michigan from the Cook Plant will not result in any harm to the lake. One of the basic concepts that Dr. Ayers has brought into focus is that the warmer water will float on the surface and be exposed to the air and that the heat will rapidly dissipate into the air. Lake Michigan will reject the heat in this manner and the temperature of the lake beyond and below the thin layer of the plume will not be influenced by the warm-water discharge of this plant. It is important to understand that his studies are not limited to laboratory findings, but involve actual field studies, including studies of powerplants that have discharged warm water into Lake Michigan for a number of years. His studies included the impact on benthic organisms and other living organisms as well as algae.

Another area of environmental considerations regarding the Cook Plant, which I believe is of relevance to this conference workshop, is aesthetics. Because our plant is located in the dune area along Lake Michigan, we have given especially careful consideration to the planning of our plant, its design, appearance and location, so that when completed, there will be a harmonious blending with the natural environment, even to the extent of using exterior surface materials that will "weather," that is, oxidize, to a compatible shade. We have adopted an entirely new concept with respect to reactor containment, with the result that the total height of the containment structure can be reduced. This will permit the construction of a low profile plant which will be hidden from the adjacent land area by the dunes and native trees. In fact, the plant will be visible only from the lake.

With respect to Interior's anonymously authored "white papers" which were issued on September 18 in an attempt to retroactively justify its proposed 1-degree temperature rise limitation, we must note the paucity of contributions from the FWQA to these reports, particularly to the report on Physical and Ecological Effects. FWQA's National Water Quality Laboratory near Duluth, Minnesota, which is under the direction of Dr. Donald Mount and which is making a major effort to determine the effects of warm-water discharges upon aquatic life, was conspicuously absent from participation in this report.

R. M. Kopper

Much of the basic argument in the report on ecological effects is based upon conditions projected for the year 2000 with no consideration of the present or of any time short of the year 2000. It misleads the reader into equating "now" with the year 2000.

The basic arguments given in this report do not include any evaluation of existing warm-water discharges, some of which are substantial. This report provides no documentation of any proven, appreciable damage from the existing discharges. The published discussion does not suggest why present discharges should be eliminated if they do no harm; nor does it address itself to why discharges from plants presently under construction will be harmful if existing discharges do no harm; also it does not tell us why discharges of the near future will be harmful. It considers only what might occur in the year 2000.

The next speaker in our presentation, Mr. David Williams, will discuss the monumental engineering changes that would be necessary to comply with the thermal discharge policies or recommendations that have been issued by Interior. He will show that the erection of cooling towers would destroy the aesthetic concept of our plant and that the other alternates would be equally offensive. He will show that these alternatives are technically unsuited for this plant at this site and at this stage of construction.

Dr. John C. Ayers will follow Mr. Williams. Dr. Ayers will summarize his studies and report on evidence regarding the effect on the lake of warm-water plumes of generating plants, and that the dimensions of these warm-water plumes are very limited.

After Dr. Ayers, the next speaker will be Mr. Fabian Polcyn, Research Engineer of the Willow Run Laboratories of the University of Michigan. Mr. Polcyn will show you some actual displays of aerial mapping of natural and industrial discharges into Lake Michigan of warm water. His photographs are evidence of the actual areas of the lake that are occupied by these warm water plumes.

In concluding my own remarks, I would simply ask that we not lose sight of the fact that the use of limited areas of Lake Michigan for industrial cooling purposes is a legitimate use of the lake and, under the law, is on a par with other legitimate uses. Thermal standards, therefore, should not prefer one such use to the virtual exclusion of other uses. Nor should thermal standards have as their goal the optimization of one such use with the result that other legitimate uses of the lake can be accommodated only to the extent that they permit such optimization. Valid thermal standards must be realistic and they must give recognition to all legitimate water uses.

I also commit my company to support continued, meaningful studies by qualified personnel in a cooperative program with the appropriate State and Federal agencies. The increased knowledge from such studies will give assurance to the public that no injury will befall Lake Michigan.

MR. STEIN: Thank you.

Are there any comments or questions?

Let me make one factual statement here, because this is something with which, at least in some other capacity I have had something to do. On the allegation of Dr. Mount's and others not participating in the report, this report was prepared by the Fish and Wildlife Service, and they were familiar with Dr. Mount's views. As a matter of fact, I had them sent over there, as well as Dr. Tarzwell's and our other experts. So they did participate in this report.

Now, I have heard this several times. You talk about anonymously authored "white papers." This is one of the issues on which I guess we may have a difference within the Federal organization. I say I am certainly sympathetic with you because my position has always been to list the names of the people who prepared these documents.

The issue here is not to preserve anonymity. One of these reports comes from the organization with which I am intimately concerned, i.e., the second one. That has an institutional preparation.

One report says, "Prepared by National Thermal Pollution Research Program, Pacific Northwest Water Laboratory and Great Lakes Regional Office," and the other does the same kind of thing. It says, "Prepared by Great Lakes Fishery Laboratory, Bureau of Commercial Fisheries, Ann Arbor, Michigan, in Cooperation with the Bureau of Sport Fisheries and Wildlife, Federal Water Quality Administration."

Now, we did this: The people who prepared these reports and who are responsible for them are here. They have appeared before you and they have answered questions. I do not think that this is a question of anonymity. However, I can sympathize with your raising the charge, not having them signed. I would hope to commend this sort of thing to our organization again. But the people are here and their names are here and they are available as the people responsible for writing these reports.

Looking at it from the Government point of view, I think, Mr. Kopper, rather than anonymity -- and I say this as the point of view that we espouse within the Government -- some people think that it is better to have an institutional representation of these things as opposed to an individual representation. I would like to say that I think it is a matter of style rather than having anyone hide behind a closet of anonymity.

Are there any other comments or questions? Are there any comments or questions from the public?

If not, thank you very much, sir.

MR. KOPPER: Yes, sir.

MR. DOWD: Mr. Chairman, because of the scheduling problem, we would like to present Mr. Fabian Polcyn. Mr. Kopper had indicated that the next speaker would be Mr. Williams. We would like Mr. Polcyn to move up to second position.

STATEMENT OF FABIAN C. POLCYN,
RESEARCH ENGINEER, THE UNIVERSITY
OF MICHIGAN, ANN ARBOR, MICHIGAN

MR. POLCYN: Mr. Chairman, conferees, ladies and gentlemen. My name is Fabian Polcyn, Research Engineer with The University of Michigan, Willow Run Laboratories. I would like to present the results of some multispectral surveys in Lake Michigan.

(Mr. Polcyn's qualifications and publications follow on Pp. 998-999)

During the last 2 years, overflights of Lake Michigan by The University of Michigan, Willow Run Laboratories have been made under sponsorship of both Federal agencies and utility contracts. More recently, two flights were made under contract with Indiana and Michigan Electric Company as part of their continuing study of the ecological factors related to thermal effluents.

We present today results of these surveys specifically those which mapped the extent of the heated effluents along the eastern shore of Lake Michigan from Michigan City, Indiana to Muskegon, Michigan.

BIOGRAPHICAL SUMMARY
for
Fabian C. Polcyn

Mr. Polcyn is a research engineer with the Willow Run Laboratory at The University of Michigan's Institute of Science and Technology. He holds a BSE (Physics) 1954 and a MS (Physics) 1958 from The University of Michigan and has been employed with the Institute since 1959. He is presently head of the Interpretation and Information Group of the Infrared and Optics Laboratory, a unit of WRL. The laboratory received an award in 1969 from the American Society of Photogrammetry for development of the Multispectral Optical-Mechanical Scanner.

Mr. Polcyn has a wide range of experience in remote sensing instrumentation and technique developments as well as applications as exemplified by the list of publications attached.

PUBLICATIONS

"Infrared", Co-author, *International Science and Technology*, April 1963.

"Infrared Scanner Observations of Volcanic Activity", Co-author, *Proc. IRIS*, Vol. 8, No. 3, August 1963.

"MORL Multispectral Experiment Definition", Co-author, The University of Michigan IST, Report 6688-1-F, August 1964.

"Comparative Multispectral Sensing", Co-author, The University of Michigan, IST, Report 2900-484-S, March 1964.

"Multispectral Data Collection Program", Co-author, Proceedings of the Third Symposium on Remote Sensing of Environment, February 1965.

"Infrared Surveys of Hawaiian Volcanoes", Co-author, *Science*, Vol. 146, No. 3645, p. 733, 6 November 1964.

"Investigations of Multispectral Image Interpretation", Co-author, Proceedings of the Third Symposium on Remote Sensing of Environment, February 1965.

"Investigation of Spectrum Matching Sensing in Agriculture", Semi-annual Report, 2 Vol., September 1967.

"Investigation of Spectrum Matching Sensing in Agriculture", Final Report, Vol. 1, November 1967.

"Remote Sensing Techniques for the Detection of Doubtful Shoals", Co-author, Ninth Meeting of Ad Hoc Spacecraft Oceanography Advisory Group, January 1968.

"How Multispectral Sensing Helps the Ecologist", Co-author, Remote Sensing in Ecology, First AIBS Interdisciplinary Meeting on Environmental Biology, June 1968.

"Analysis of Lake Michigan Data", Preliminary Science Report, Co-author, Report 8973-13-L, November 1968.

"Remote Sensing Techniques for Location and Measurement of Shallow Water Features," Co-author, Report No. 8973-10-F, January 1969.

"Effects of Atmospheric Path on Airborne Multispectral Sensors" Co-author, Report 1674-5-T, January 1969.

"Applications of Multispectral Remote Sensing Techniques in Water Pollution Control", Co-author, 157th National Meeting of the American Chemical Society, April, 1969.

"Taking a New Look at the Lakes", *LIMNOS*, Vol. 2, No. 2, p. 12, Summer 1969.

"Water Depth Determinations Using Remote Sensing Techniques", Co-author, Proceedings of the Sixth International Symposium on Remote Sensing of Environment, October 1969.

"Potential Applications of Remote Sensing to Oceanography and Hydrology", Co-author, presented at the Remote Sensing Principles and Applications To Earth Resources Survey Seminar, Paris, France, November 1969.

"Multispectral Remote Sensing Study of Industrial Discharges," Co-author, presented at the 25th Annual Purdue Industrial Waste Conference, Purdue University, May 1970.

"Analysis of Multispectral Data of the Santa Barbara Oil Slick", Co-author, Final Report 3340-4-F (in publication).

"The Measurement of Water Depth by Remote Sensing Techniques", Co-author, Final Report 8973-26-F, (in publication).

F. C. Polcyn

The sensor system used in most of these flights collects light in the ultraviolet, visible, and the thermal infrared wave lengths, simultaneously. Thus, the color of the water and any temperature patterns can be mapped to learn their mixing patterns and to measure their area of influence. The infrared radiation observed by this airborne method comes from only the surface of the water, and since the warmest waters are usually least dense, the surface patterns are a reliable measure of the maximum spatial extent of a given temperature interval. Thermal contours were made by electronically isolating a signal for each degree of temperature, beginning with ambient lake temperature and ending with the warmest temperature present in the thermal plumes. Each degree of temperature was assigned a color, and a display of the temperature mixing pattern was formed.

Three types of results will be presented today in a series of slides. These include the discharges around existing plumes, the temperatures at sites not yet in operation, and naturally-occurring temperature patterns many of which are greater than 1 degree of temperature. Now, we will supply negatives for these slides at a later date.

If we could now look at the series.

MR. STEIN: I should mention that we do not reproduce color, so when these appear in the report everything will be in black and white.

MR. POLCYN: I am sorry to hear that.

MR. STEIN: Let me go off the record just for a second here.

(Discussion off the record.)

MR. STEIN: Back on the record.

MR. POLCYN: Thank you.

... Slide ...

The first slide is showing a map of Lake Michigan.

Two flights were flown, one on 11 August 1969, and the other on 7 May of this year. Fossil powerplants at Michigan City and Port Sheldon, two proposed nuclear plant sites, one at Bridgeman (Cook Plant) and one at Palisades as well as the St. Joseph River outfall were mapped.

... Slide ...

Color Aerial Photograph of Harbor at Michigan City, Indiana, 11 August 1969

The area shown is 1-1/2 mi. x 3/4 mi. The distance across the harbor is 2,000 ft. The harbor, river, marina, and plant site can be readily seen. Sediment

F. C. Polcyn

in the harbor water can be detected due to the light yellow hue. Lack of any pronounced current due to the wind is evident by the uniform pattern of distribution across the harbor.

... Slide ...

Color Code for Temperatures, 11 August 1965

The temperature range for each color is shown in the table. In general, as color shifts from blue to red, the temperatures increase.

... Slide ...

Color Coded Thermal Contour of Harbor at Michigan City, Indiana, 11 August 1969

The image here is 2-1/4 mi. x 3/4 mi. Temperature pattern can be seen by observing distribution of each color. A 4.4 degree F. difference was measured between the lake temperature (dark blue) and warmest part of discharge plume (sepia). The reason this Delta T is smaller than the 11 degrees F. across the condensers is that the intake pipe is below the river's surface where the water was measured to be almost 4 degrees F. colder; also, there is some cooling as the water flows down the discharge canal. The size of the warmest portion is only of the dimensions of the width of the river channel, approximately 270 ft. Cooling of the warm plume takes place continuously so that relatively small areas are influenced by waters even 2 degrees F. above ambient lake temperatures. For this day, the warmer waters were confined inside the harbor barrier and no recycling of the heated water was present.

... Slide ...

Color Aerial Photograph of Harbor at Michigan City, Indiana, 7 May 1970

Distribution of sediment in harbor is different in comparison with Slide 2 taken on 11 August 1969. Edge of current (movement of suspended sediment) can be seen at the upper right just above harbor breakwater.

MR. STEIN: Let me interrupt. Maybe counsel wants to consider this, but since this depends so much on color, I would suggest you consider putting these in as an exhibit, so we have these on file in Washington and in the regional office . If anyone has to go to this, we can produce slides, I know it is going to lose a lot of its impact if it gets to black and white. Would that be agreeable?

MR. DOWD: We would prefer to do it that way, because colors are so integral to this presentation.

MR. STEIN: That is the essence of the presentation.

MR. DOWD: Exactly. we will do that.

MR. STEIN: Right.

MR. FETTEROLF: Mr. Polcyn, would it be possible to have Mr. Ayers point with the pointer and to point out some of these areas you are speaking about?

MR. POLCYN: I think that is possible, or Mr. Stewart is nearer by the screen. He could perhaps point them out.

MR. FETTEROLF: Is there a pointer available? Let's hope Mr. Stewart has a long arm.

MR. MAYO: While we are waiting for Mr. Stewart to come up, at the time the photographs were taken were on-the-site ambient temperatures taken?

MR. POLCYN: At each site personnel from the plant -- there were plant personnel taking ground measurements, surface measurements.

Now, there is evidence of current flowing eastward due to wind from WSW (at 13 knots). Muddy water was due to several days of rain which caused Trail Creek to be very turbid. The plant was taking this water, pumping it through the condensers, and discharging it into the harbor.

... Slide ...

Color Code Table for Temperatures, 7 May 1970

F. C. Polcyn

... Slide ...

Color Coded Thermal Contour of Harbor at Michigan City, Indiana, 7 May 1970

Temperature range and distribution is seen to be different in comparison to 11 August 1969, data. The area shown in this slide is 2-1/2 mi. x 1-1/2 mi. Strong winds (from west) affect surface waters most readily and thus warm waters are pushed eastward against breakwater. Warmest water (Magenta) at outfall is 10 degrees F. warmer than lake water temperature (dark blue). Water at temperature 3.4 degrees F. above lake temperatures can be seen flowing past breakwater similar in distribution to sediment pattern of Slide 5.

Due to the springtime heating of land faster than water, temperatures about 6 degrees F. (orange color) warmer than lake temperatures (dark blue) can be seen all along shoreline. This naturally-occurring heating of shore waters should be noted for its greater importance in contributing to lake temperature rise because of the wider area of influence along the entire shoreline compared to the localized area of plant discharges.

... Slide ...

Water Masses at Harbor at Michigan City, Indiana, August 11, 1969

F. C. Polcyn

Shown here is the result of multispectral processing of the visible data to obtain different water masses in an area 3 mi. x. 1 mi. path. The tan, sepia, violet, and cyan areas show varying kinds of deeper lake water. This apparent turbidity in the water was probably due to the two previous days of strong winds from the NW. The dark blue area in the harbor shows the distribution of river water. The marina shows up strongly as a contributor to this particular kind of water in the harbor.

... Slide ...

Water Masses in Harbor at Michigan City, Indiana, 7 May 1970

The water mass distribution as seen on this day is quite different from that observed on 11 August 1969.

In the 4 mi. x 1-1/4 mi. area shown, dark blue shows the deeper lake water, the pastel blue shows the pattern of nearshore waters heavily laden with sediment. The medium blue inside the harbor corresponds to sediment pattern seen in Slide 5 and the dark green shows river water entering harbor.

A small patch of river water (dark green color) can also be seen at the discharge point of the plant effluent. This suggests the relatively small influence the cycling of river water by the plant for cooling purposes has on the harbor area. Under strong winds (13 knots, WSW) the near-shore currents appear to dominate the harbor waters.

... Slide ...

Discharge Plumes at Campbell Plant, Port Sheldon, Michigan, as Function of Wind

Plumes shown were taken at three different times under widely separated wind conditions. The top plume was obtained on 7 May 1968, when a SE wind of 14 knots was blowing. The strong wind blows the plume to the north and NW. Most of the warm water has been cooled by the time it reaches the right-hand edge of the picture (about 1/2 mi.)

The middle plume was obtained on 26 September 1968. The wind for this day was out of the NW at 10-12 knots. The velocity of the discharge carries the warm water straight out for a few hundred yards before the wind blows it back towards shore. The distance from the discharge point to the harbor breakwater is 3/4 mi.

The bottom plume shows the effect of both wind and current. The wind for this day (11 August 1969) was 4 knots out of the SE but a strong 2-day wind out of the NW had just ended 9-12 hours earlier. The relatively calm wind is just beginning to effect the shallower water as evident by the portion of the plume seen near shore to the north of the discharge canal.

We see by this evidence that the warmer water near the surface is most easily moved about by changes in wind direction. We also see that no accumulation of warmer water is found in any given place. In fact, although a larger area may be covered because plumes can be found north and south of the discharge channel, a given receiving point will experience a variable contact with the warmer discharge waters and hence will not be heated continuously. In other words, wind direction changes produce a spreading of the heat over a larger area and thus increases the heat exchange to the surroundings.

... Slide ...

Color Aerial Photograph of Palisades Nuclear Plant Site, Michigan, 11 August 1969

The construction at the site is clearly visible on the lower right corner of the 1-1/2 mi. x. 1-1/8 mi. area shown. The sediment which has been placed in suspension by 2 days of NW winds can be seen near shore as compared to the deep blue waters offshore. The very light area in the water off the plant site is a sand bar built up because of a sunken barge located there.

... Slide ...

Reproduced from best available copy.

F. C. Polcyn

Color Coded Thermal Contour of Palisades Nuclear Plant Site, Michigan, 11 August 1969

It is apparent that very little temperature pattern is present off the site which is as one would expect since no thermal sources are near. A naturally-occurring 1-degree variation is seen towards the middle of the picture which is probably due to an upwelling of colder water. The area shown is 3/4 mi. x 3 mi.

... Slide ...

Water Masses at Palisades Plant Site, Michigan, 11 August 1969

The image represents an area 1 mi. x. 3-1/4 mi. Although few temperature gradients were noticed (Slide 12) there is a mixture of different water masses inshore while the deeper water shows little change. This shows the naturally-occurring change in water quality due to strong winds before plant is placed in operation.

... Slide ...

Water Masses at Palisades Nuclear Plant Site, Michigan, 7 May 1970

Although the wind was stronger this day as compared to 11 August and also heading in a different direction, there was no previous history of poor weather to stir the water and produce the changing water masses as

F. C. Polcyn

seen before on 11 August 1969. The sunken barge area can be seen quite clearly in this picture.

... Slide ...

Thermal Imagery of Donald Cook Plant Site, 7 May 1970

Warmer land area appears brighter in the picture. The Cook Plant Site is located to the left of the middle of the slide.

... Slide ...

Water Masses off Donald Cook Nuclear Plant Site, Bridgeman, Michigan, 11 August 1970

The area shown is 3 mi. x 1 mi. Again, the turbulence caused by the preceding 2 days of strong weather is shown by the water mass patterns. The Cook plant site is along the shore near the left middle of the slide. These particular patterns suggest that some effluent from the St. Joseph River might have been swept past the site by the storm.

... Slide ...

Color Code Table for St. Joseph River, 11 August 1969

... Slide ...

Color Coded Thermal Contour of Benton Harbor/ St. Joseph, Michigan, 11 August 1969

F. C. Polcyn

As can be seen for this time of year the temperature difference between the river water (blue-green) and lake water (cyan) is 1.4 degrees F. The direction of the river flow is due to a slight SW wind blowing at that time. The dimensions of the image are 2-1/4 mi. x 3/4 mi.

... Slide ...

Water Masses at Benton Harbor/St. Joseph, Michigan, 11 August 1969

The dark green area (3/4 sq. mi.) shows the effluent from the river while the dark and pastel blues show water masses in deep and shallow water. It is possible that the river was turbid due to increased runoff from land due to the storm and this is what is being emptied into the lake. Area shown covers 3 mi. x 1-1/2 mi.

... Slide ...

Color Code Table for Temperature, 7 May 1970

... Slide ...

Color Coded Thermal Contour of Benton Harbor/St. Joseph Harbor, Michigan, 7 May 1970

Compared to 11 August, a very dramatic change takes place in the river-lake relationship during the spring. Because the land is warmer than the lake, the river water has warmed up considerably while the lake water, being a much larger body of water, still remains quite cold. The difference in temperature between the warmest part of the river (red) and the deep lake water (dark blue) is 14.9 degrees F. The heating of the shallower waters near shore is also evident by yellow and orange strips near shore. Even these areas are more than 8 degrees F. warmer than the deeper offshore water.

... Slide ...

Infrared Image of Thermal Bar in Lake Michigan

This strip of infrared imagery was taken with an infrared scanner at 12,000 feet on 7 May 1968, along the eastern shore of Lake Michigan between Port Sheldon and Muskegon, Michigan, a distance of 30 miles. The darker tones represent cooler temperatures than the lighter ones. In the lower edge toward the right, the outfalls of the Grand and Muskegon Rivers can be seen as bright plumes. Temperatures measured across "thermal gradient" seen offshore were about 4 degrees F. The large areas of these thermal anomalies generated naturally by the warmer temperatures of the land during the day in spring place in better perspective the relative contribution of warm waters discharged locally by power generating plants and that produced by the natural environment along many miles of shoreline.

In summary, we have shown pictorially the relatively small area of influence due to heated discharges from plants presently operating along Lake Michigan. We have shown how the temperature contours distribute across the plume and how they are influenced by the wind changes. Finally, we have shown examples of naturally-occurring temperature gradients in the lake, many of which lie between 4 degrees and 15 degrees F. higher than the background water temperature and extend over areas much larger than what is observed at power generating plant sites.

MR. FETTEROLF: Mr. Polcyn, A PT appears on that slide that would take in a shoreline area which includes the candle point.

MR. POLCYN: Yes, it is off to the very left corner, if Mr. Stewart would try to point to it. It is just barely seen. It is much smaller than the outfalls from the Grand River and the St. Joseph River. We would have to see this picture much closer to just see it.

MR. FETTEROLF: The large warm water masses which are shown there are not due to the influence of river flows or heated discharges?

MR. POLCYN: As we saw from the colored bank across the edge of the shoreline in the spring pictures in these previous slides, one would have to conclude that the effect of land heating and water seems to be bigger -- this is shown here, the orange band across -- it extends for every mile along the shoreline. In my judgment it would be this mechanism which probably leads to heating, although there is bound to be some minor influence by the rivers and the plants, but it seems -- the major contribution would have to be by this extended heating source.

MR. STEIN: Are there any other comments or questions from the conferees or any from the public?

If not, thank you very much, Mr. Polcyn, for a very interesting presentation. Without objection, the slides will be entered as exhibits and will be available in Washington at Headquarters and at our Regional Office and be available for inspection during normal business hours. Of course we will make them available to anyone who wants to evaluate the report. I think that is probably the best way to handle this.

(The above-mentioned slides are on file Headquarters, FWQA, Washington, D.C., and the Great Lakes Regional Office, Chicago, Illinois.)

May we continue?

MR. DOWD: Our next speaker is Mr. David Williams.

STATEMENT OF DAVID H. WILLIAMS, JR., ASSISTANT VICE PRESIDENT AND CHIEF MECHANICAL ENGINEER, AMERICAN ELECTRIC POWER SERVICE CORPORATION, NEW YORK, NEW YORK

MR. WILLIAMS: Mr. Chairman, conferees, ladies and gentlemen. I am David H. Williams, Jr., Assistant Vice President and Chief Mechanical Engineer of the American Electric Power Service Corporation.

(Mr. Williams' qualifications appear on P. 1016)

Mr. Chairman, it is my intent to use some slides during my presentation and we will make a duplicate set of the slides available to you, too.

MR. STEIN: Are these colored ones, too?

MR. WILLIAMS: Some of them are, yes, sir.

MR. STEIN: Let's see. Again, make your judgment whether you want them reproduced in black and white in the report or handled as exhibits, and you don't have to do that right now. Maybe we can see what they look like.

MR. WILLIAMS: Fine.

The design of the Donald C. Cook nuclear plant utilizes the cooling capacity of Lake Michigan as a

D. H. Williams, Jr.

D. H. Williams, Jr. is Assistant Vice President and Chief Mechanical Engineer. In this position he is responsible for the mechanical engineering activities of the American Electric Power System.

Mr. Williams received his B.S. and M.S. in Mechanical Engineering from Virginia Polytechnic Institute in 1953 and 1954, respectively. In the period 1954-1956, he was a lieutenant in the U.S. Army Corps of Engineers, Company Commander in a construction battalion.

Mr. Williams joined the AEP Service Corporation in 1956 as an engineer responsible for the startup of several new large turbine-generator installations, including maintenance and operating procedures. In 1961, he was appointed Head of the Turbine Section of the Mechanical Engineering Division, with responsibility for all turbine activities in the AEP System. In 1963, Mr. Williams was appointed Project Engineer, in charge of design studies and coordination of design activities for the Cardinal Plant which consists of two 600 Mw units. He was promoted to Assistant Chief Mechanical Engineer in 1965 and to Chief Mechanical Engineer in 1967.

Mr. Williams was elected to his additional, present position of Assistant Vice President in July 1968.

Mr. Williams is a member of The American Society of Mechanical Engineers and Pi Tau Sigma.

natural resource to provide vital low cost electric energy to the consumers in Indiana and Michigan Electric Company's service area and on the AEP system. From the initial design concept we have followed the philosophy of utilizing the lake water for cooling without abuse or harmful effects to the health, safety or welfare of the public. Also of primary importance in the design has been the concept of keeping the plant site as aesthetically pleasing as possible.

The cooling water for the two-unit plant is brought into the plant structure through three 16-foot diameter pipes which extend some 2,280 feet out into the lake. The water intake into each of these pipes is a steel crib structure located on the bed of the lake some 12 feet below the surface. Each of the three intake structures is designed with a screen having eight inch openings to avoid the possibility of drawing large objects into the pipes. Where the pipes enter the plant structure, the water then passes through rotating screens and is then pumped by seven circulating water pumps through the unit condensers and is discharged back to the lake through two pipes. These discharge pipes extend approximately 1,200 feet out into the lake.

The concrete portion of the circulating water pump house as well as the sinking of the intake and discharge pipes into the lake is well under way, as is shown in these slides. All the cooling circuits in the plant have been designed and the equipment purchased. In most cases this equipment is in the final stages of production or has been shipped to the job site.

To consider an alternate scheme for cooling at this point in time would require a drastic redesign of a number of major components which would have the immediate effect of delaying the generating capacity of this vitally-needed plant, reducing the efficiency and plant output and, while not of primary concern here, but nevertheless an important factor to our customers, is the fact that there would be a significant increase in the cost of the plant. It is our firm belief that the existing design will meet the requirement of having no harmful effect. It is our position, therefore, that an alternate cooling means would have no beneficial effect on the lake or to the general public.

In discussing alternate cooling methods in powerplant design, I would like to point out that the American Electric Power Company is probably the leader in the utility industry in the development and application of natural draft wet cooling towers. The first such tower designed and installed in this country went into service in 1963 on a 275-MW unit at our Big Sandy Plant in eastern Kentucky. This was the first so-called hyperbolic natural draft cooling tower built in this country. This tower is some 320 feet high and has a base diameter of 245 feet. Since this first tower was built, we have designed and built a natural draft tower for a 600-MW unit which went in service in 1968. This was followed by the construction of five 800-MW units located in three different plants, each utilizing a single natural draft cooling tower for condenser cooling. We are presently in the process of designing and constructing a 1300-MW fossil unit which will utilize a single natural draft cooling tower with a diameter of 400 feet at the base and a height of 495 feet. This tower has the capability of cooling 600,000 gallons/min. of water by 20 degrees F. This gives a heat rejection rate of 6 billion B.t.u.'s/hr. The physical size of this tower is dramatic. It could hold the playing field of White Sox Park. The Marina Towers could fit with ease inside this tower.

It has been, and continues to be, our position that design of each generating facility should be approached on the basis of a thorough study of water requirements, heat discharge and environmental effects. In applying for the water-use permit from the State of

Michigan, the cooling tower concept was considered for the Cook Nuclear Plant. However, after taking all things into consideration, it was felt that no sound environmental purpose would be served by the construction of cooling towers at this site -- quite the contrary, that the public interest would be best served by utilizing the lake for cooling. The point is -- and our record bears this out -- that the AEP system does not hesitate to go to cooling towers where they are needed.

We have given careful consideration to the recently proposed 1 degree F. rise limitation for Lake Michigan. The longer we looked into the problem the more overwhelming and impractical the possible solutions became and we arrived at the following general conclusions based on the design of our plant.

There are two basic approaches to the problem of designing for 1-degree F. rise. The first being to maintain the present once-through cooling concept, but to discharge the warm water back to the lake with a temperature not to exceed 1 degree F. above the ambient lake temperature. The second alternative is to design a closed loop cooling system utilizing either a cooling pond, wet cooling towers or so-called dry cooling towers. This study parallels to a modest extent the recently received document from the U. S. Department of the Interior, "The Feasibility of Alternative Means of Cooling For Thermal Powerplants Near Lake Michigan." The closed loop systems would, however, require the use of Lake Michigan water, but would avoid any significant flow of warmed discharges directly to the lake.

Taking dilution as the first case, we start with a designed circulating water flow requirement of 1,500,000 gal./min. This water provides cooling to the main turbine condensers as well as to a number of plant auxiliary systems including those within the reactor building itself. With the present design, the discharge temperature at maximum licensed output on both reactors is some 21 degrees F. above the lake ambient temperature.

In order to bring this within the rise limit of 1 degree F., we calculated the dilution required to reduce the discharge temperature by mixing prior to discharge to the lake. This would necessitate a flow rate of about 20 gallons of unwarmed water for each gallon of warmed water in order to achieve the 1-degree F. limit at the point of discharge.

We would have to use the lake waters for dilution and this would require a colossal pumping system which would handle a flow of some 77,500 cubic feet per second.

D. H. Williams

This is equivalent to pumping the average flow of the entire Ohio River at its mid-point. Pumps with high flow capacity and low head or discharge pressure would be needed. Commercially this type of pump is available at capacities ranging from 150,000 to 500,000 g.p.m. If we use a typical pump rated at 300,000 g.p.m. and 20-ft. head, we would need 100 such pumps with a total installed power requirement of approximately 180 MW. This would represent a consumption of approximately 8 percent of the total plant electrical output to the customer. The cost of the pumps alone without motors or structure would exceed $15 million.

It would require 40 pipes 16 feet in diameter to bring this water into the dilution facility. This facility would be extremely complex because of the absolute necessity of mixing to achieve a uniform 1-degree F. discharge limit. The total installed cost of such a facility would be in the order of $230 million. As engineers and designers, we feel that this dilution scheme would be a totally impractical solution to meet the 1-degree F. condition.

With respect to a closed cooling loop design, one alternate would be the wet type hyperbolic or natural draft cooling tower as previously mentioned. At a

D. H. Williams

minimum, we calculate that a three-tower structure would be required to serve the two-unit plant. These towers would each handle approximately 500,000 gallons per minute. The dimensions of these towers would be 400 feet at base diameter and 500 feet in height or the same physical size as the tower previously mentioned.

Since the design of the plant is complete and construction is quite far along, we would be forced to maintain the same condenser flow rates and we, therefore, would have to operate the two units at higher condenser back-pressures. Based on a cooling tower performance approach temperature of 18 degrees F., the summer cold water temperature would average approximately 90 degrees or some 14 degrees F. above the maximum expected lake temperature. At these water temperatures, the expected condenser back-pressure would increase from 2.9 inches of mercury to 4.3 inches causing a load curtailment of approximately 40 MW per unit or some 80 MW for the total plant.

The natural draft cooling tower requires an unrestricted air flow around its base. Three cooling towers of the size indicated would require a minimum of 30 acres of flat, cleared land. This would necessitate the destruction of a sizeable portion of the sand dune area. A second pumping system in addition to the present designed condenser circulating water pump system would be mandatory to transport the cooling water from the condenser discharge to the cooling towers. The cooling towers would have to be at a higher elevation than the plant in order to gravity flow the cooled water back to the circulating water pump suction, thus making the towers even more conspicuous.

Since the reactor safeguard systems have been completely designed for expected lake temperatures and reviewed by the Atomic Energy Commission, an increase in cooling tower temperature levels would require major equipment modifications and resubmittal of the safeguard design to the AEC.

Based on today's labor rates, a rough estimate of the cooling tower costs would be $18 million. This excludes excavation, pumps, structures and other piping costs and overheads. Labor constitutes at least 40 percent of the total cost of cooling towers. With a continuation of current construction wage escalation, the cost of these towers would exceed $20 million at the time of installation. The pumping and transport systems through the cooling towers and back to the plant is estimated to cost in excess of $12 million.

D. H. Williams

Cooling towers also involve the problem of handling wastewater discharge such as cooling water blowdown to control dissolved solids. Based upon limits adopted by some State agencies, it is assumed that the dissolved solids concentrations would exceed the effluent limits allowable for discharge directly back to the lake and that this blowdown water would exceed the 1-degree F. limit. Therefore, a large soak pond or land disposal system would have to be installed in order to avoid discharge of water directly to the lake.

Another closed system would be a large cooling pond. To build such a pond would require the acquisition of a suitable block of land for a lake having a minimum size of 5,000 acres. We feel that this system would constitute a totally unacceptable use of the land resources of this area.

Dry cooling towers have been discussed as a possible method of avoiding warm-water discharges. We feel that for the Cook Plant they are totally out of the question because of the limited experience with such cooling facilities. With a dry cooling tower, the cold water cooling temperatures are substantially higher than ambient air temperature. During the summer months this would create a condenser pressure of 8 inches to 14 inches of mercury. Turbines which have been designed and are being manufactured for the Donald C. Cook Plant cannot operate much above 4 inches of absolute mercury without overheating and causing distortion of the casings. As far as the cost of any dry cooling system, there are no reliable figures which would be applicable because the largest such system in service in the world today is for a unit of approximately 150 megawatts at Ibbenburen, Germany. There must be more development on smaller conventional plants before a dry cooling system can be applied to nuclear plants of the size of the Cook Station.

If we are required to meet the 1 degree Fahrenheit rise limitation, it would mean scrapping a major portion of the equipment and design. This would result in a substantial delay of a year or more in the production of over 2 million kilowatts of electric power that is sorely needed to meet the normal requirements of the people in this part of the country. More important is the fact that the present design of the Cook Nuclear Plant, to the best of our knowledge (and this knowledge is based on extensive technical research) will not be harmful to Lake Michigan. Furthermore, it is our firm belief that the possible alternatives would be extremely objectionable to the public, and not in their best interests because of the unnecessary waste of human and financial resources.

We would like to comment briefly on the document from the Department of Interior issued on September 18, 1970, entitled "The Feasibility of Alternative Means of Cooling for Thermal Power Plants Near Lake Michigan." We believe it should be clearly understood that the economic evaluation contained in this "white paper" applies to the construction of wholly new plants on ideal new sites and that the cost and efficiency figures in this report do not apply to the backfitting of cooling equipment onto existing installations or those under construction.

The feasibility of dry cooling towers has stirred the interest of the general public since all the heat would be discharged directly to the air without any effect on the surrounding waters. It is well known that both mechanical draft and natural draft evaporative cooling towers have been built for large units. Dry towers have been built, but the largest size in service today, as stated before, is only 150 megawatts. The turbines for the dry tower installation must be designed to operate with back pressures as high as 14 inch mercury on days when the ambient temperature is high. In addition, there would be other cooling design problems, such as lubricating oil, and the reactor and nuclear steam supply components which require a cooling temperature lower than that which can be achieved with the dry type tower. By this we are not saying that it is technically impossible to design a nuclear plant with a dry type cooling tower for condenser cooling. We are saying, however, that it is virtually impossible to apply the dry tower to an existing plant or one under construction. We feel that a great deal of work needs to be done by the turbine manufacturers before units of the 1,000 megawatt and higher size can be produced for dry cooling tower application.

There is very little doubt that the electric utility growth will continue to double every 10 years to meet further load demands. If we continue to do things exactly as we are doing them today without any change, then it could be said that the potential heat release input to Lake Michigan from power generating stations may increase more than tenfold in the next 30 years or by the year 2000. This country, let alone the utility industry, cannot possibly afford to continue to generate power exactly as we are today. If we go back 30 years in time to 1940 and look at the means of generating power that existed at that point in time, we would find that the largest single generator size was approximately 50 to 60 megawatts with a design unit efficiency of 10,700

B.t.u.'s per kilowatt hour. This is to be compared with the most efficient plants being designed today -- units in the size range of 1,000 to 1,300 megawatts with heat rates of 8,800 B.t.u.'s per kilwatt hour. If we step aside and look at the ingenuity that has gone into the design, construction, and operation of the vast electrical energy system which supports the economic growth and strength of the country today, then surely we can meet the demands of the future with respect to heat release problems and cycle efficiencies.

In conclusion, the overall public interest requires that there be a balanced consideration of environmental effects against other considerations affecting the public interest, including specifically the public interest in assuring adequate electric power to meet the needs of the next several years.

Any material interference with the operations or the imposition of any substantial delay in the bringing into being of plants in operation, under construction, or now on the planning boards to meet loads in the next several years will materially impair the ability to assure adequate electric power for such years.

Accordingly, it is unsound and improper to attempt to establish proposed solutions for plants in existence, under construction, and on the planning boards on the basis of assuming the consequences of an aggregate of heat which might be discharged in the year 2000 on the assumption that future plants will be built on the lake without limitation.

The public interest requires the use of sound judgment in balancing the effect on the environment of warm water discharges against other alternatives which frequently may have greater adverse effects on the environment.

In many areas along the shore of Lake Michigan, the use of enormous cooling towers or large ponds would, as a matter of aesthetics and optimum land-use, have a much more detrimental effect on the environment than the warm water discharge associated with the properly designed heat discharge system.

MR. STEIN: Thank you, Mr. Williams. I don't know about those slides. They are kind of marginal. I expect at least the first few are not going to come out with any justice to black and white.

MR. DOWD: We would propose to submit several copies of those in color also as exhibits if this is agreeable.

MR. STEIN: All right. I think that would be better. Those pastels in the first just would come out a blur, I am sure.

MR. DOWD: We will do that.

MR. STEIN: They will be received as part of the record without objection. (See Pp. 1031-a through 1031-l)

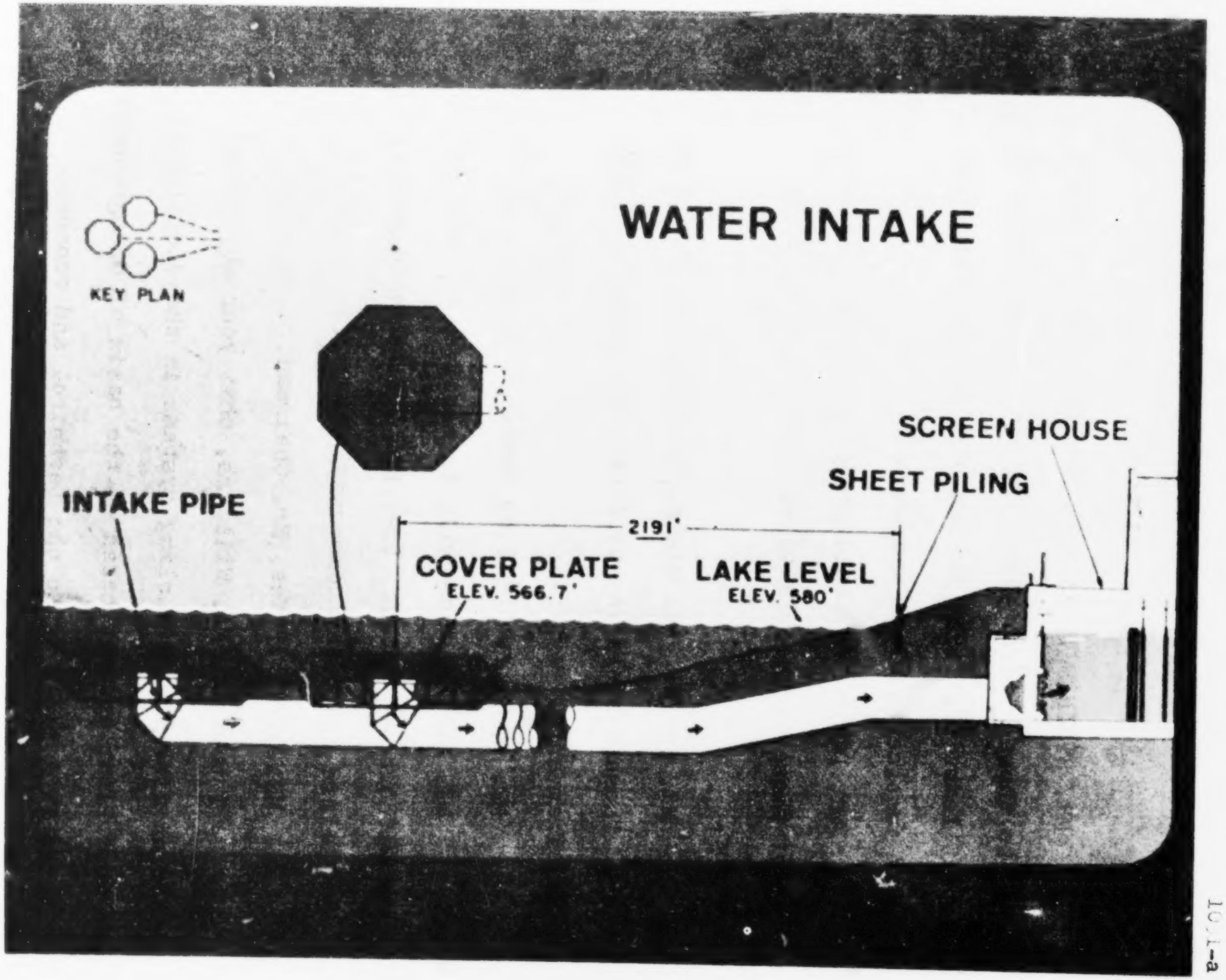
Are there any comments?

MR. CURRIE: Yes, Mr. Chairman.

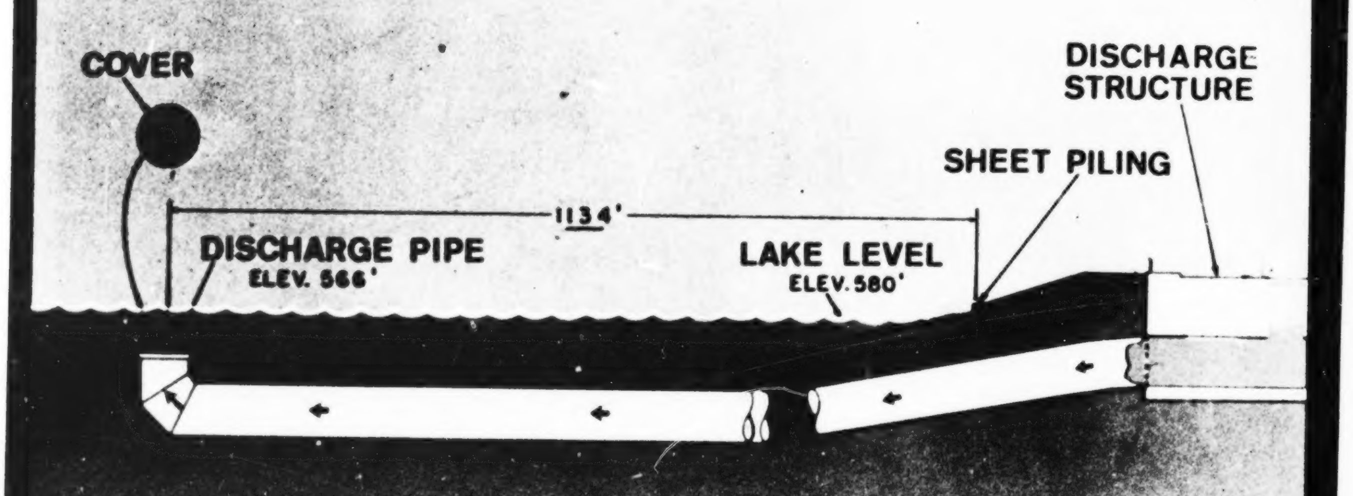
I take it, Mr. Williams, that your objections regarding alternative cooling systems in the vicinity of the Cook Plant are not based on the basis of disagreement with the FWQA paper as to the technical and economic feasibility of cooling towers, for example, under other conditions, that is, in other geographical locations and as to plants which are not already under construction, is that right?

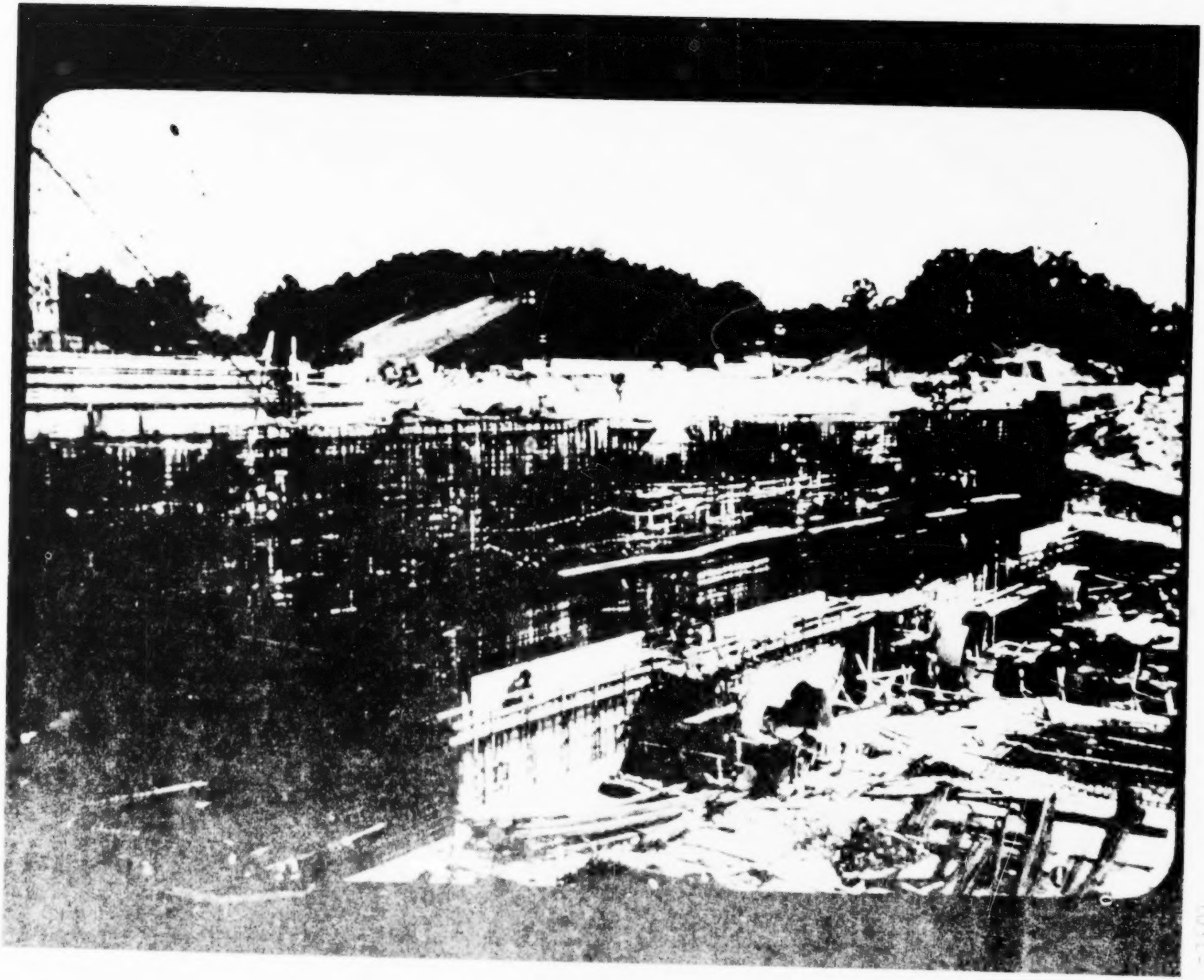
MR. WILLIAMS: If I understand you correctly, yes.

WATER INTAKE

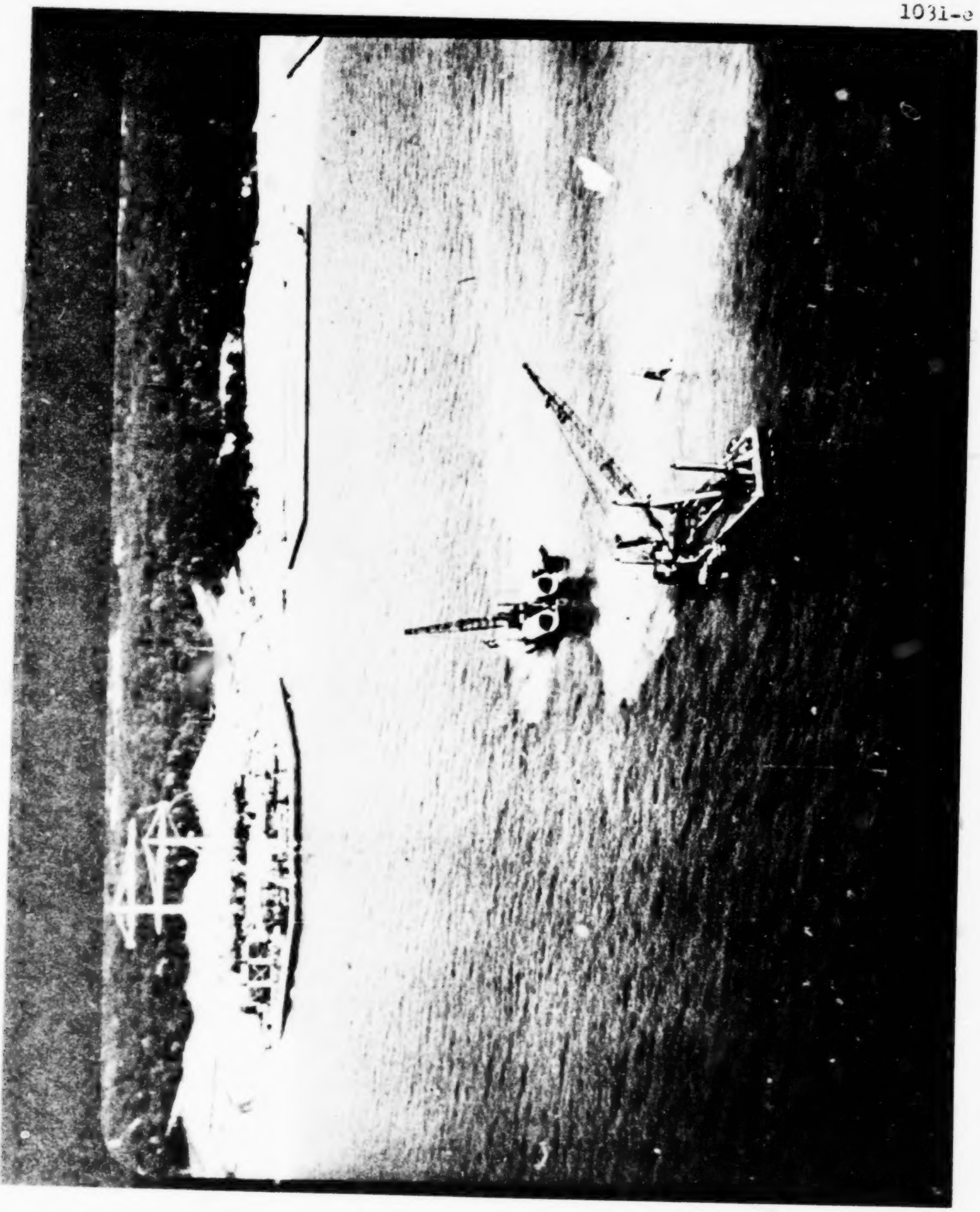


WATER DISCHARGE

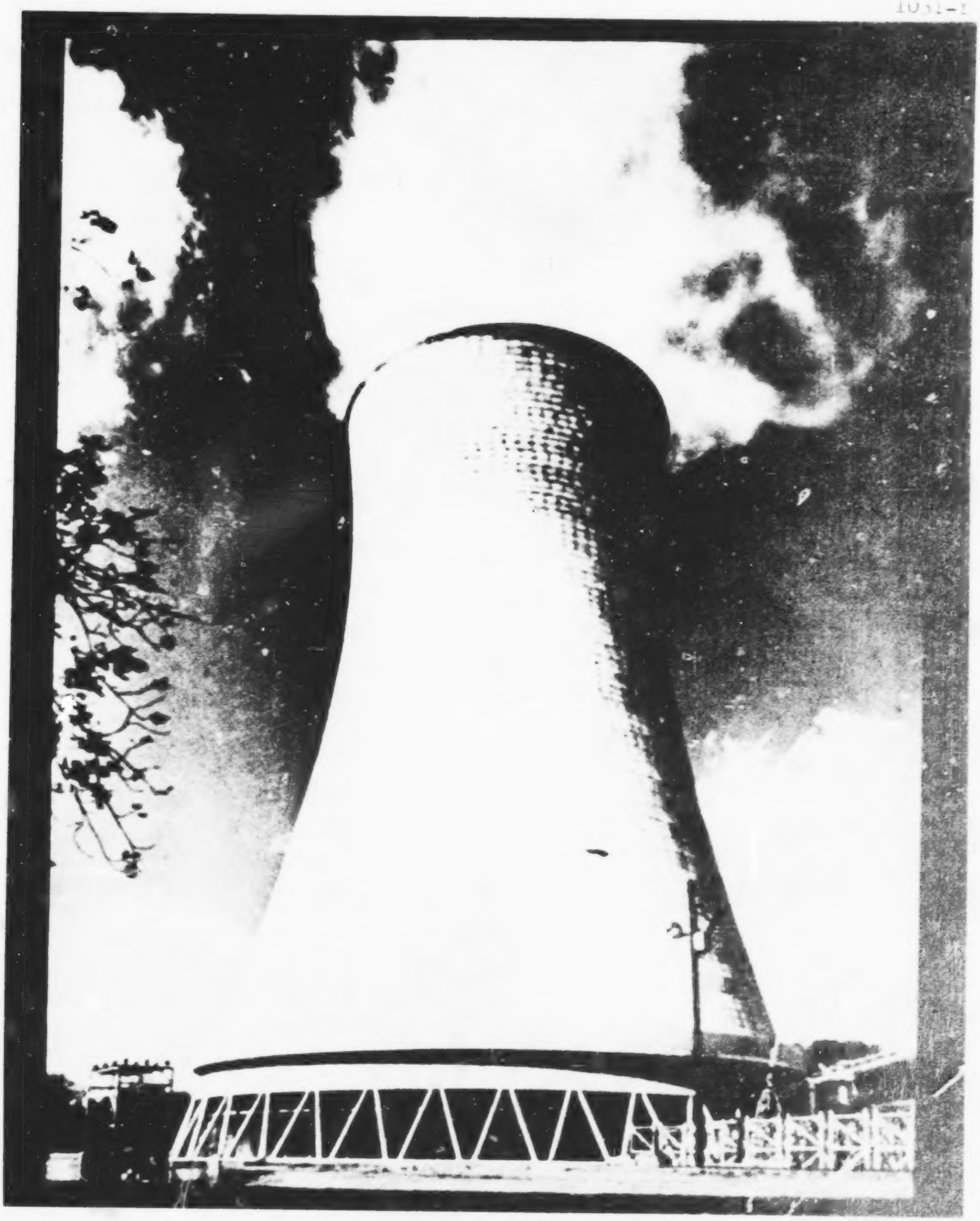




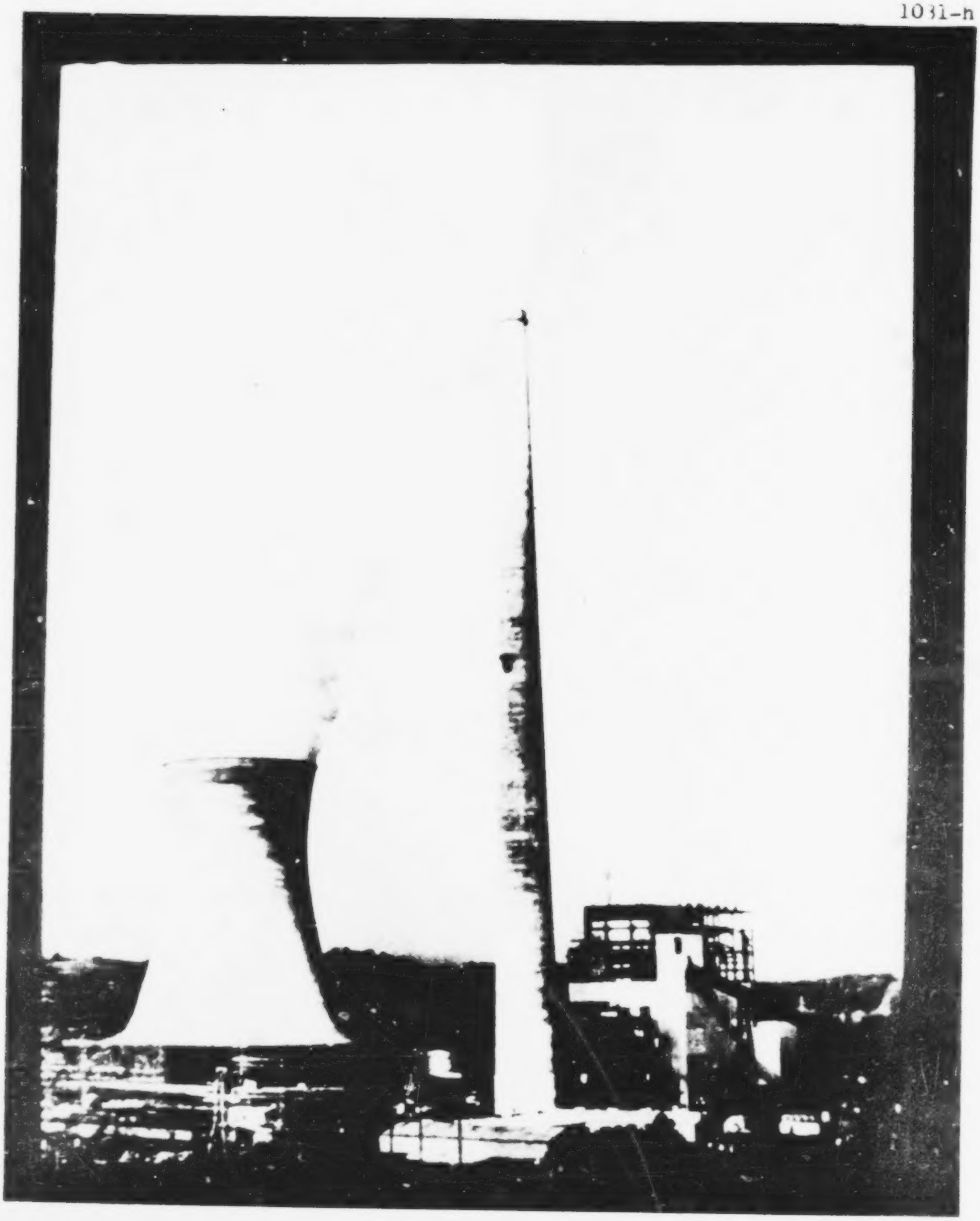
1031-e

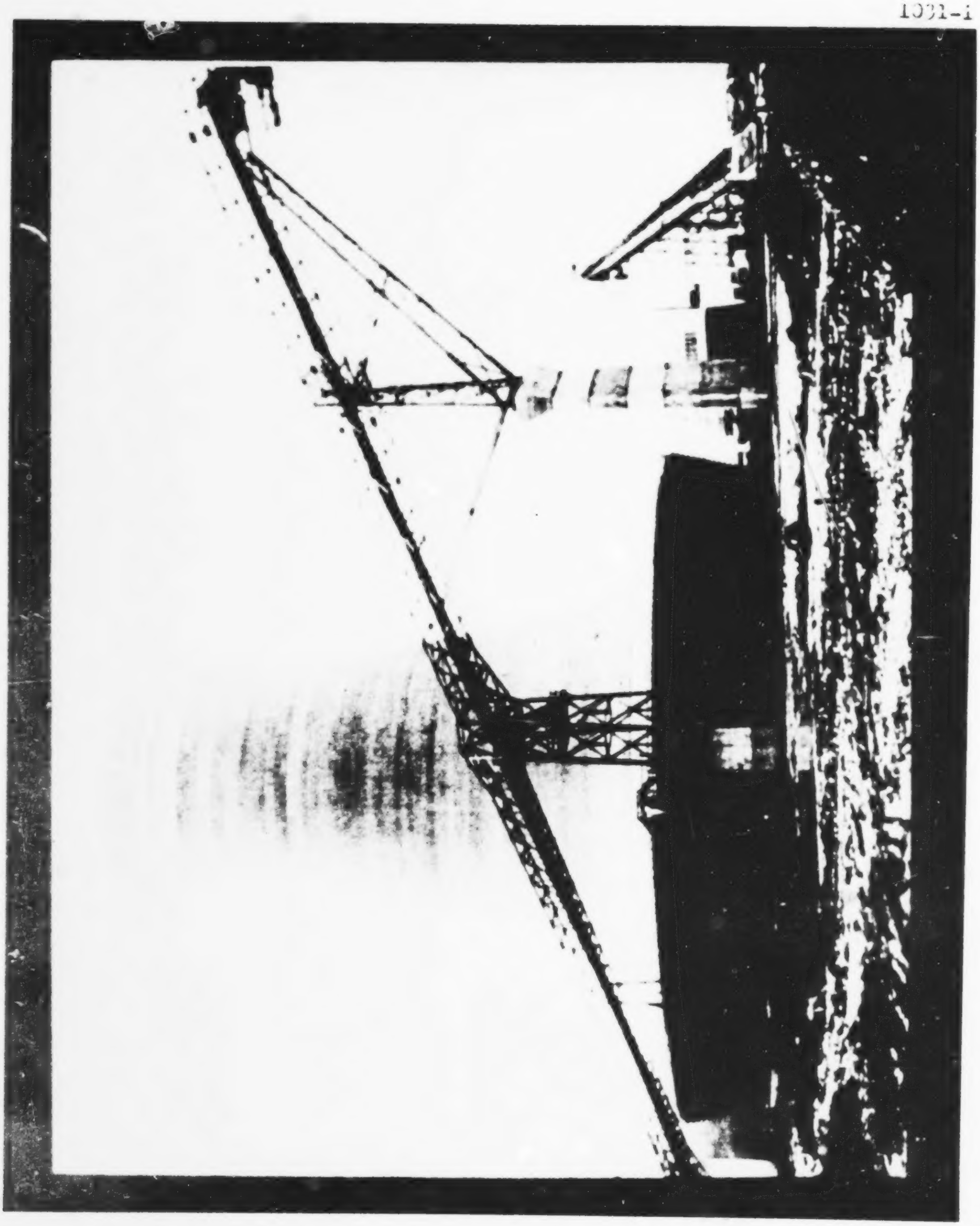


1031-1

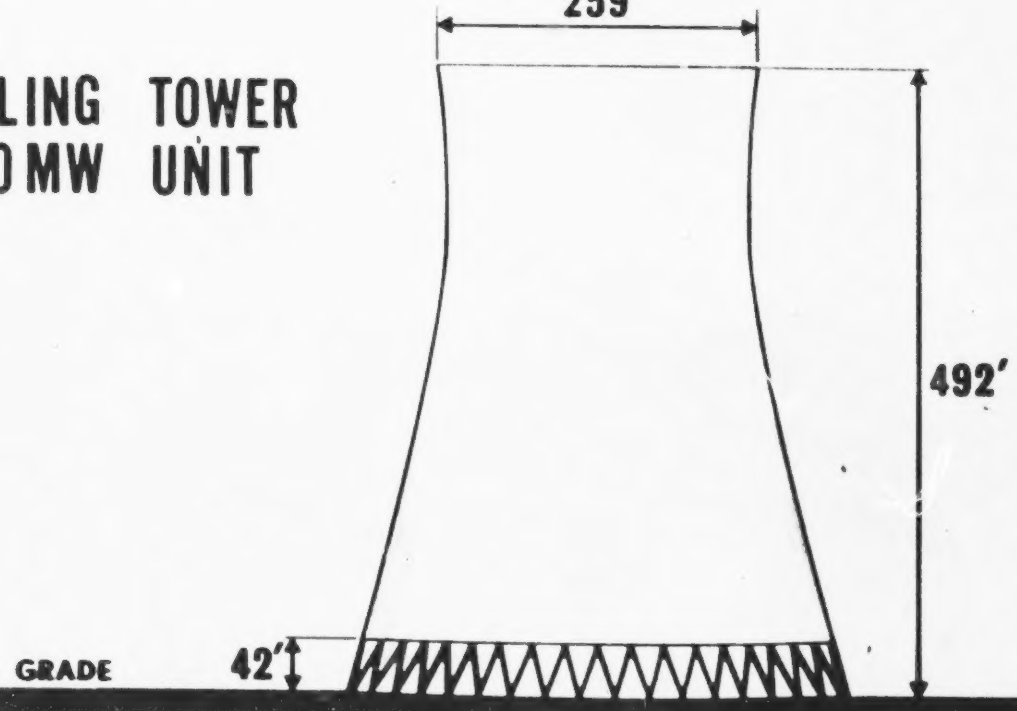


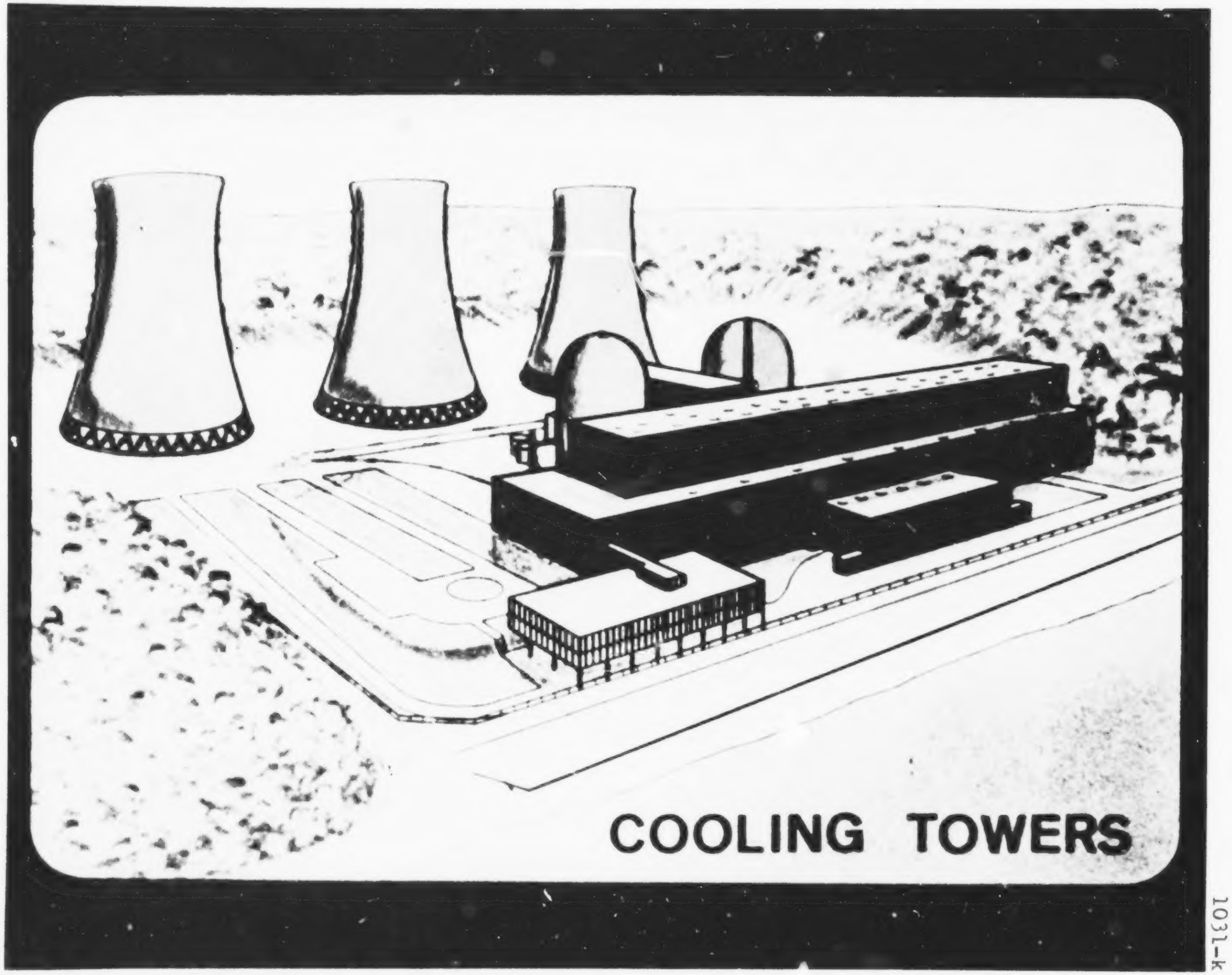
1031-g



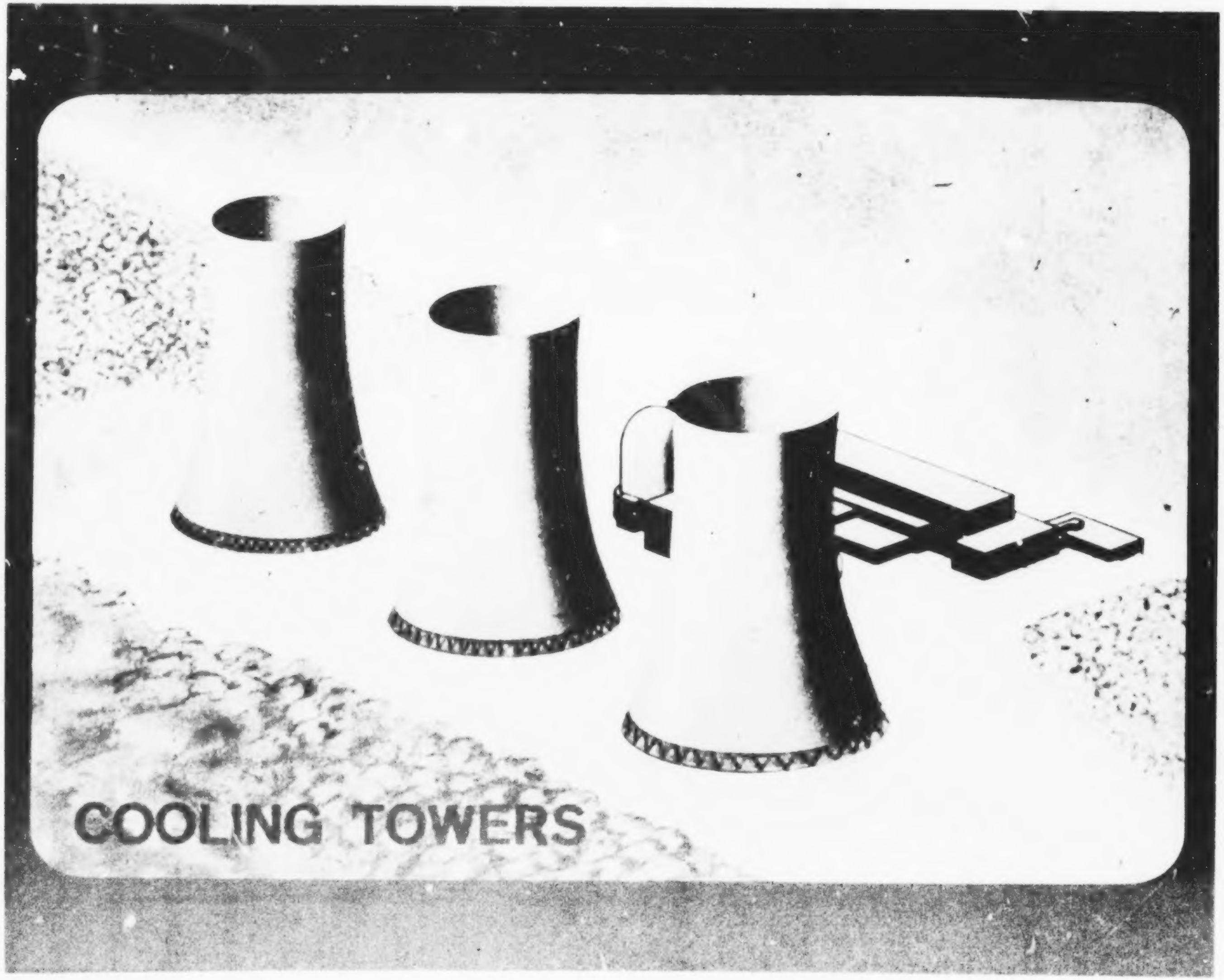


COOLING TOWER
1300 MW UNIT





COOLING TOWERS



COOLING TOWERS

MR. CURRIE: You are referring, then, to the fact that the site chosen is somewhat unfavorable in your view for such devices as cooling towers?

MR. WILLIAMS: That is correct.

MR. CURRIE: Now, who chose the site? Did any State or Federal agency choose that site?

MR. WILLIAMS: I would like to call on some of my colleagues to help answer that.

MR. CURRIE: Well, I don't think I really expected an answer.

MR. STEIN: I think when you ask a question they should be given the privilege of answering if they want to.

MR. KOPPER: I am Mr. Kopper. I think we have to look the history over of who is responsible over the years for selecting powerplant sites and building powerplant systems. The utilities have been assigned this responsibility, and I think we performed under this responsibility all of these years of selecting the sites in light of the total problem.

The total problem involves fuel supply, adequate water for cooling, finding the access routes for transmission lines to take the power from the plant and deliver it to the load center. This is a total composite factor here. There is also a very strong factor which we have been under tremendous pressure on over the years, and that is to develop economics in all facets of our business to provide the public with low cost power and, therefore, in selecting a site, this is another important factor. So I think you have to take all these factors into consideration, and we have been given that responsibility under law to build a system -- we accept a franchise and operate under franchise to build a system and provide power to the public in the area. Does that help the situation?

MR. CURRIE: I think the question really is: Why was not the possibility that pollution control equipment might be required also taken into account in selecting this site and also in beginning construction of this plant. I take it Mr. Williams' additional point is that dry cooling towers would be particularly difficult here because of the backfitting problem, because the plant has been constructed so far in such a way as to make backfitting very difficult.

I take it that decision -- the decision to ignore the possibility that pollution control equipment might be required, the decision to build it in such a way as to make backfitting difficult -- was also not a decision dictated by a State or Federal agency but rather was your own decision.

MR. KOPPER: Yes, sir, it was our own decision, but this decision was made on the basis that there would be no pollution that would be harmful to the public and to the lake by building the plant on this site.

MR. WILLIAMS: I would also like to comment there, sir. I tried to give the impression that it would be impossible to backfit with a dry tower on this installation.

MR. STEIN: Are there any other comments or questions?

By the way, I think you have given some valuable information on this analysis. Again, I think we are beginning to get a pattern, as I see it, of these industries' position on this: 1) that the heat discharged into Lake Michigan is creating no damage; 2) that the heat that enters the water is primarily deflected into the air and that if any damage results or all the heat is not deflected, heat damage is temporary and not cumulative; 3) that we shouldn't impose positions today which may affect loads going into the lake in the year 2000; and 4) that whatever we do, the regulatory agencies should not deal, as we have at other plants, with existing plants, but exempt existing plants, those under construction, and those on the planning boards; but if they are going to come up with a future operation, that should apply to only plants which are not even on the planning boards yet. I get that as a theme through all of the presentations.

I think this is a -- what I consider -- reasonable summary so far of the things that I find from the power companies.

Will you come up, Mr. Dumelle?

MR. DUMELLE: My name is Jacob Dumelle, a member of the Illinois Pollution Control Board.

Mr. Williams, you mentioned that the American Electric Power Company has seven very large cooling towers built and one under design. I wonder if you would comment on the experience of the company with fog and ice conditions from these existing cooling towers, because that is one of the arguments which has been raised against them. I realize this varies by site possibly, but of the sites where they are in operation, what has been the experience?

MR. WILLIAMS: I would be glad to comment on that, sir: In addition to the natural draft towers which I showed on the slides, we also have the 675 megawatt plant on the mechanical draft dry towers. Since the installation of these towers, we have been conducting primarily in the winter months surveys of exactly what plume configurations exist from the discharge of these towers under various atmospheric conditions.

With respect to fog, as far as ground level fog or icing conditions, we have had excellent experience in that there have been no reported problems from these towers. However, this is a substantial visible plume which extends upwards of 4,000, 5,000 feet in the air that can be seen from quite some distances on cold winter days.

MR. DUMELLE: What about snow fallout or icing conditions?

MR. WILLIAMS: We have tried to observe this very closely, and we have had no adverse conditions.

MR. DUMELLE: How do you design these plants and what do you do during periods of high humidity when the wet bulb temperature is very close to the dry bulb temperature? Do you reduce the plant output or just what?

MR. WILLIAMS: Mother nature does that for us. The back pressure, of course, increases and the turbine or the capability of the turbine generating power reduces and we keep the same input to the turbine and the generator produces accordingly as the back pressure goes up.

MR. STEIN: Are there any other questions from the audience?

If not, thank you very much.

MR. CURRIE: Mr. Chairman, may I ask one more?

MR. STEIN: Yes.

MR. CURRIE: What do you do about blowdown in your cooling towers?

MR. WILLIAMS: The plants we are designing today and have in existence utilizing cooling towers, we have designed what we call a wastewater scheme whereby we take backup water into the cooling tower basin. We then withdraw water from that basin to handle our bottom ash system which automatically acts as a means of blowing down. This water is then taken to a bottom ash pond where we also pump any other plant's wastewaters.

We take the water from this pond back to the plant and utilize it for our fly ash handling system, and we take all of the combined wastes which would include the cooling tower blowdown, mix them together, and put them in our fly ash pond, which is a long-time settling area. An effluent which takes a week's time for the solids to drop out and is a combined mixture of all these wastes may require treatment before it evaporates to the atmosphere or overflows back to a local river or stream.

MR. CURRIE: So that you combine this problem of blowdown with the other water pollution problems created by a fossil plant, which are not the same as those of a nuclear plant, is that right?

What would you do if you had a nuclear plant with blowdown?

MR. WILLIAMS: Again, with the State restrictions on allowable effluent standards, as I stated in the paper, in all probability we would try to devise some kind of evaporative or soak pond or some type of facility.

MR. STEIN: Are there any other comments or questions?

Thank you very much.

MR. WILLIAMS: Yes, sir.

MR. PETERSEN: I have one question.

My name is O. K. Petersen, and I would like to know if you have made any studies of the comparable climate conditions between existing plants and the site of the proposed Cook Plant and if you have, do you have any conclusions as to the difference in climate or likeness of climate as the case may be between operations which might affect the operations of the cooling tower at the Cook Plant site.

MR. WILLIAMS: I will try to answer that in that if you consider the Cook site -- and under the supposition that we were required to come in with an alternate cooling facility -- if we looked at all of the alternatives -- I mentioned that land is totally out of the question in that area as far as the cooling ponds. Dry towers are an impossibility because of the turbine problems which I mentioned with existing turbines that we have.

This leaves the alternative of mechanical draft or natural draft cooling towers. Mechanical drafts would definitely be ruled out based on our experience with the number required. The interstate highway which was near a powerplant with a low level of vapor discharge that you get there from the mechanical towers, I feel, would definitely be a problem with relation to the highway.

With the natural draft tower, with the plume discharge plus its heat -- 500 feet in the air -- this is not a problem.

So far as meteorological studies, that would have to be my response, as to the only practical approach with regard to the cooling plant condition.

I don't know if I have answered what you really were getting at.

MR. PETERSEN: Very well, except for one small area, and that is: Would there be any conditions of freezing within the cooling tower due to possible lower temperatures and high winds coming in off the lake during the winter?

MR. WILLIAMS: Never having operated a tower on the lake -- and I know the wind blows quite hard -- I think this would be a design problem.

We have been able to overcome this problem at other installations where we have nowhere near the prolonged wind and the cold air. I think it would be a problem. But I think it is technically possible to overcome it.

MR. STEIN: With that, let me just ask one last question. I don't expect you to speak for all of the industries, but maybe you can for the industry around here. You do indicate that you have selected a site and you have put something on the planning boards where if something is asked or required, you may then consider a device to protect the environment. You say that we are not going to get the counter argument that the site is such that the meteorological conditions are bad and it can't be done, that it is near a road, that it is near an airport or near a congested area because you are picking these sites as we go along, or as your industry develops.

Now, when can we expect or is there going to come a time when the power industry picks the site and can say it has taken these conditions into account just in case people responsible for the environment might ask, and therefore these are not going to be interposed as objections anymore?

MR. WILLIAMS: I would rather not speak for the industry, but I think generally the approach is that in the selection of any site today -- and I think we have to start talking from today -- these are definitely to be taken into consideration as to what the future might bring as far as requirements on this plant, where we can do these things with the technical tools we have at that time.

MR. STEIN: All right.

Are there any other comments or questions?

Thank you very much.

I think with all the things we have to do, there is just one way to do it. We will go until just about 12:00 o'clock and then recess until 1:30 for lunch. We will adhere to that schedule because a deviation, again I think, might give certain problems for this evening especially and would slow things up.

Would you continue, sir?

MR. DOWD: Our final speaker is Dr. John C. Ayers of the University of Michigan.

STATEMENT OF JOHN C. AYERS, PROFESSOR OF OCEANOGRAPHY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

DR. AYERS: Mr. Chairman, conferees, ladies and gentlemen. I am John C. Ayers. I am a Professor of Oceanography at the University of Michigan. I hold a Bachelor's Degree in chemistry and Master's and Doctoral degrees in zoology. I received 5 years of on-the-job training in oceanography at the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts.

I have been engaged in research on the Great Lakes since 1954. I am presently in my eleventh year of research on Lake Michigan, and in my seventh year of research on those types of inshore phenomena that apply to electrical generating stations.

My inshore studies have included the warm-water discharges from electrical generating stations and the naturally-warmed discharges from rivers entering into Lake Michigan.

I have personally investigated the plumes of warmed discharge water from generating plants at Big Rock Point near Charlevoix, Michigan; at Muskegon, Michigan; at Port

Sheldon, Michigan; at Michigan City, Indiana; at Burns Ditch, Indiana; at Waukegan, Illinois; and at Port Washington, Wisconsin. I have studied the results of surveys by others of generating plant discharges in Lakes Erie and Huron as well as Lake Michigan. I have studied the results of surveys by others of generating plant plumes on both the east and west coasts and in other parts of the country.

I have personally studied the discharges of the Milwaukee and Grand Rivers into Lake Michigan.

(Dr. Ayers' qualifications and publications appear on Pp. 1044-1046.)

Let me get into the record at this point that I am a conservationist, that I know the literature of laboratory tests which show heat to produce undesirable effects on organisms or environmental parameters, and that I am engaged in studies of releases of real waste heat into the real environment because I fear the potential effects of this heat as much as do the concerned conservationists who appear in such numbers at every public hearing.

Because I am a conservationist, my work is addressed to the very same questions that the conservationists raise. In what I am about to say, I speak only to these problems in connection with real heat rejection to the real Great Lakes, I have not personally studied them in other

JOHN C. AYERS Professor of Oceanography, Department of Meteorology and Oceanography; Research Oceanographer, Great Lakes Research Division, University of Michigan

Born: Marcellus, Michigan, October 4, 1912.

Education:

Kalamazoo College	AB in Chemistry, 1934
Kansas State College	MS in Zoology, 1936
Duke University	PhD in Zoology, 1939

Positions Held:

Instructor in Biology, Univ. of South Carolina, 1939-41.
Adjunct Prof. of Biology, " " " 1941-43.
Instructor, Physics & theory of flight, U. S. Naval Flight Prep. School, 1943-44.
Research Associate, Woods Hole Oceanographic Institution, 1944-49.
Asst. Prof. of Oceanography, Cornell University, 1949-52; Assoc. Prof. 1952-56,
Assoc. Prof. of Zoology, Univ. of Michigan, 1956-58; Prof., 1958-63.
Research Director, Great Lakes Research Institute, Univ. of Michigan, 1956-60.
Research Oceanographer, Great Lakes Research Division, Univ. of Michigan, 1960-.
Prof. of Oceanography, University of Michigan, 1963-.

Scientific Societies:

American Society of Limnology and Oceanography
  Vice President 1962-63; President 1963-64.
  Chairman, Comm. on Education & Recruitment 1961-.
  Co-chairman, Program Committee, 1964-.
American Association for the Advancement of Science
Sigma Xi Honorary Society
International Association for Great Lakes Research

Professional Activities:

Member of Corporation, Marine Biological Laboratory, Woods Hole, Massachusetts, 1953-.
Official collaborator, Marsh Ecology Research, N. Y. State Dept. of Conservation. 1958.
General Chairman, Third Conference on Great Lakes Research. 1959.
Consultant to Power Reactor Development Company, 1958-1961; Canadian-American Committee on Great Lakes Water Pollution, 1959; Upper Peninsula Office, Michigan Dept. of Health, 1959; Huron-Clinton Metropolitan Park Commission, 1960; Consumers Power Co., 1961; American Electric Power Service Corporation, 1966-; Oxford Paper Co., 1967-68; Toledo Edison Co., 1968-; Great Lakes Basin Commission, 1968-.

Principal Publications:

Relationship of habitat to oxygen consumption by certain estuarine crabs. Ecology, 19: 523-527, 1938.

Action of antifouling paints. VI. Effect of nontoxic pigments on the performance of antifouling paints. (With B. H. Ketchum) Ind. & Eng. Chemistry, 40, p. 2124, 1948.

The oceanography of New York Bight. (With B. H. Ketchum and A. C. Redfield.) Pap. in Phys. Oceanog. & Meteor., 12(1) 46 pp., 1951.

The principal fouling organisms. Chapter in *Marine Fouling and Its Prevention*. (With H. J. Turner.) pp. 118-164. U. S. Naval Institute, Annapolis, Md., 1952.

A method for rendering wood resistant to marine borers. Bull. Mar. Sci. Gulf & Caribbean, 3(4): 297-304, 1954.

Population dynamics of the marine clam, *Mya arenaria*. Limnol. Oceanogr., 1:26-34, 1956.

Currents and water masses of Lake Huron. (With D. V. Anderson, D. C. Chandler, and G. H. Lauff.) Pub. No. 1, Great Lakes Research Institute, Univ. Michigan, 101 pp. 47 figs., 12 tables, 1956.

A dynamic height method for the determination of currents in deep lakes. Limnol. Oceanogr., 1:150-161, 1956.

Simplified computations for the dynamic height method of current determination in lakes. (With R. W. Bachmann) Limnol. Oceanogr., 2:155-157, 1957.

Currents and water masses of Lake Michigan. (With D. C. Chandler, G. H. Lauff, C. F. Powers, and E. B. Henson.) Pub. No. 3, Great Lakes Research Institute, Univ. Michigan, 169 pp., 52 figs., 16 tables, 1958.

The hydrography of Barnstable Harbor, Massachusetts. Limnol. Oceanogr., 4:448-462, 1959.

Sources of hydrographic and meteorological data on the Great Lakes. (With C. F. Powers and D. L. Jones.) U. S. Fish & Wildlife Serv. Spec. Sci. Rept.--Fisheries No. 314, 183 pp., 1959.

Water transport studies in the Straits of Mackinac region of Lake Huron. (With C. F. Powers.) Limnol. Oceanogr., 5:81-85, 1960.

The bottom sediments of the Straits of Mackinac region. (With G. H. Lauff, E. B. Henson, D. C. Chandler, and C. F. Powers.) Pub. No. 6 Great Lakes Research Division, Univ. Michigan, 1961.

A portable photocell fluorometer for dilution measurements in natural waters. (With V. E. Noble.) Limnol. Oceanogr., 6:457-461, 1961.

Great Lakes waters, their circulation, and physical and chemical charcteristics. P. 71-88 *in* "Great Lakes Basin," Pub. No. 7, American Association for the Advancement of Science, Washington, D. C. 1962.

Hydrology of Lakes and Swamps. (With James H. Zumberge.) Section 23 (33 p.) in Handbook of Applied Hydrology. Ven Te Chow, Ed. McGraw-Hill, N. Y. 1964.

The climatology of Lake Michigan. Univ. Michigan, Great Lakes Research Division Pub. No. 12, 1965. 73 p.

The people, the alpha and the omega. Kalamazoo College Review 24(2): 15-17, 1967.

Studies on the environment and eutrophication of Lake Michigan. (With D. C. Chandler, Eds.) Univ. Michigan, Great Lakes Res. Div. Spec. Rep. No. 30, 1967. 415 p.

Current patterns and lake slope. (With F. R. Bellaire.) Proc. 10th Conf. on Great Lakes Res., p. 251-263, 1967.

environments.

Since this conference bears upon the ultimate establishment of standards for thermal inputs into Lake Michigan, it is logical as background material to ascertain something about the natural inputs of heat to which Lake Michigan is accustomed and adapted.

These heat inputs are primarily 1) direct input of heat from the sun of which there are several computations, and 2) inputs of heat delivered to the lake by rivers which have collected it in the shallow waters and large areas of their watersheds. I speak here to the latter of these two items.

The Grand River, which opens to the lake at Grand Haven, Michigan, is situated on the east side of Lake Michigan to which the prevailing southwest winds push warmed surface water from the lake. Heat input from the Grand River, then, is an injection of heat into some of the warmer waters of the lake.

The long-term mean outflow of the Grand River is 1,500,000 gallons per minute, comparable to the discharge of a large nuclear generating station.

Let us see how the temperatures of the Grand River discharge compare to those of the ambient lake water in spring, summer, and fall.

J. C. Ayers

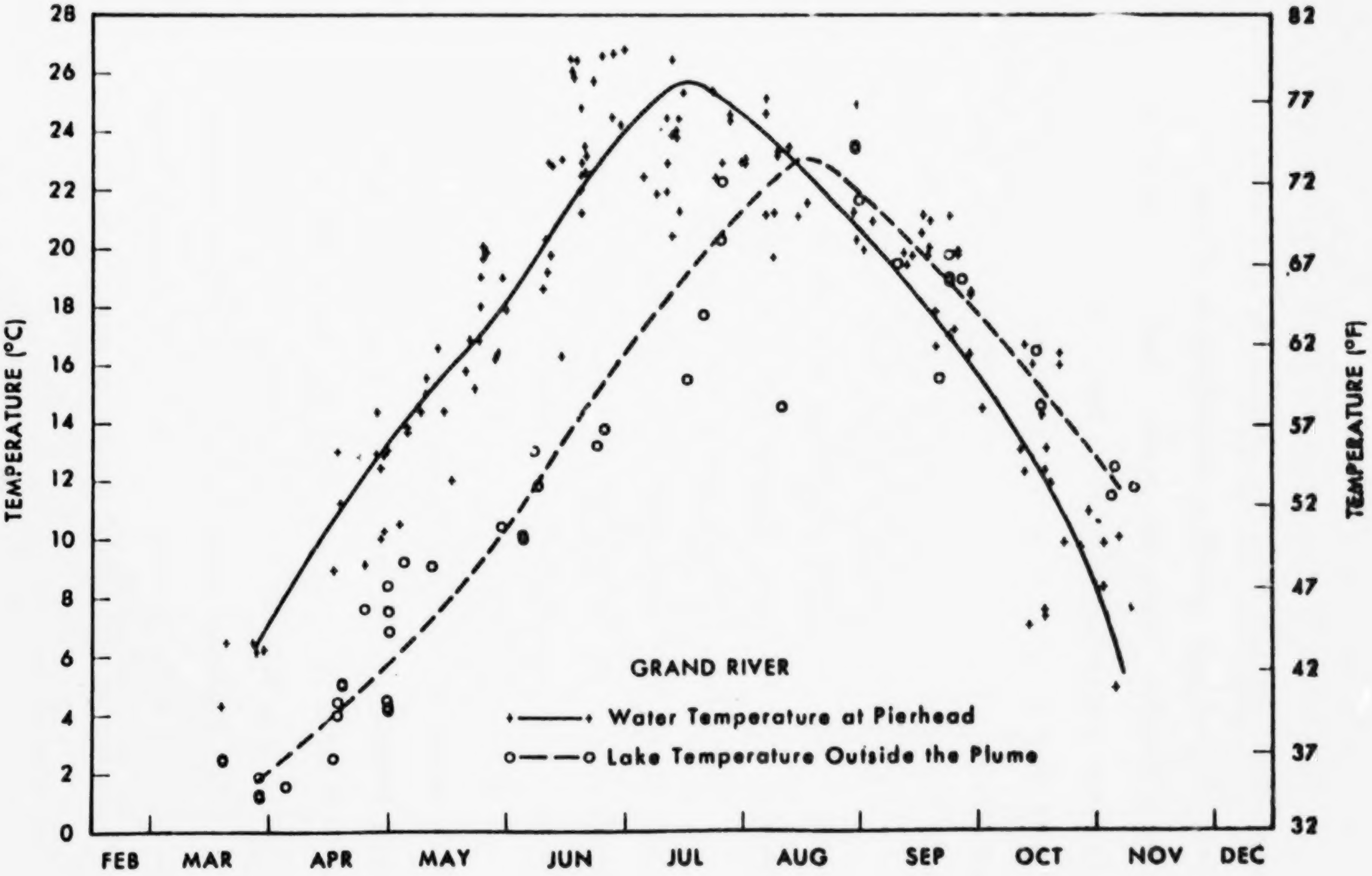
... Slide No. 1 (See P. 1049) ...

Even in March the river water entering the lake is warmer than the lake. The temperature difference increases steadily into July, but fall cooling has begun by August and river temperatures soon fall below those of the lake water.

From mid-March through July the Grand River waters reaching the lake average 7 to 12 degrees F. warmer than the lake. It is reasonable to expect that this has been the case during all the years since the deforestation of its watershed.

On the west side of the lake the prevailing southwest winds blow off from the shore and surface water is pushed out into the lake. The west-shore rivers consequently discharge much of the time into cold upwelled subsurface water. The temperature differences between river water and lake water on that side should be even larger than at the Grand River.

It is difficult to understand the need for a plus 1 degree F. thermal standard for the inshore waters of Lake Michigan when for generations these waters have received from their tributaries natural inputs of 7 to 12 degrees or more of excess temperature during the critical spring and summer seasons.


28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
TEMPERATURE (°C)
82
77
72
67
62
57
52
47
42
37
32
TEMPERATURE (°F)
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
GRAND RIVER
Water Temperature at Pierhead
Lake Temperature Outside the Plume

J. C. Ayers

Consideration of thermal standards are inspired by very proper concern over the possibility that waste heat will hasten the eutrophic deterioration of Lake Michigan's waters. Among the several sources of waste heat are electric generating stations. They are contributors of heat, but they are not the only contributors of heat. Investigations of waste heat and its effects could, then, properly begin with the waste heat of generating stations.

Our investigations of waste heat rejection to the lake cover seven different generating stations to date, and some of them have been visited more than once.

The nature and behavior of the plumes of warm discharge water from these plants are fundamental matters in determining what, if any, effects their rejected heat has on the aquatic ecology of the lake.

Electric generating stations are attracted to the lake shore by the large volume of cooling water that the lake provides. The cooling water they use is drawn from the inshore water of the lake, and the warmed water is released back into the inshore water.

The dominant condition of water current movement in the inshore water is that of alongshore currents being present and moving the warmed discharge water parallel to the shore.

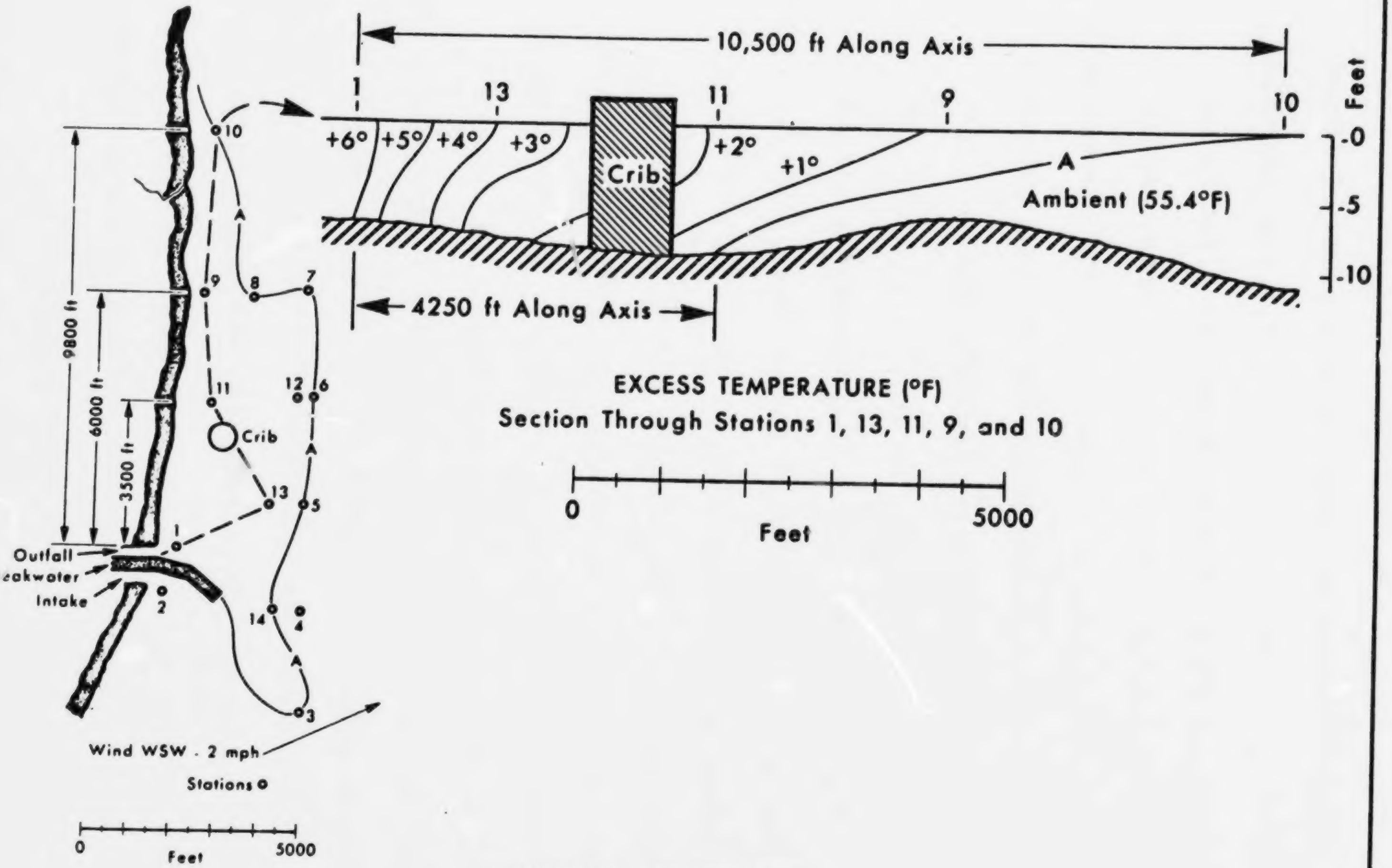
J. C. Ayers

To illustrate the behavior of a plume of warmed discharge water in the usual condition of its moving with the alongshore current, we have chosen the plume of the Waukegan, Illinois, generating station of Commonwealth Edison as we observed it on 30 June 1969. The current this day was definitely northward under the residual influence of strong south wind during the previous night.

... Slide No. 2 (See P. 1052) ...

This shows the layout of our sampling stations, and the vertical distribution of excess temperature in a section along the lengthwise axis of the plume. In both the station layout and the section, a line labeled "A" indicates the beginning of ambient lake temperature, which in this case is 55.4 degrees F. Distances indicated in the section are distances along the axial line indicated by dashes in the station layout at the left. Distance along the beach is shown on the beach at the left of the station layout. Station 1 gives the vertical distribution of excess temperature observed just outside the end of the plant's discharge channel as far in as the survey boat could go. The rest of the section shows the vertical distribution of excess temperature along the plume axis.

Along the bottom, ambient temperature was reached at 4,250 feet along the axis from Station 1. At the water



EXCESS TEMPERATURE (°F)
Section Through Stations 1, 13, 11, 9, and 10

WAUKEGAN - 30 JUNE 1969

surface ambient temperature was attained at 10,500 feet from Station 1. Rapid loss of excess temperature is shown along the surface of the section, where more than 4 degrees F. of the 6 degrees F. of excess temperature was lost in the 4,250 feet along the axis to Station 11.

The tendency of the warmest water to float on cooler water begins in the isotherm of plus 5 degrees above ambient immediately beyond Station 1 and becomes progressively more evident from there outward along the section until warmed water leaves the bottom at 4,250 feet.

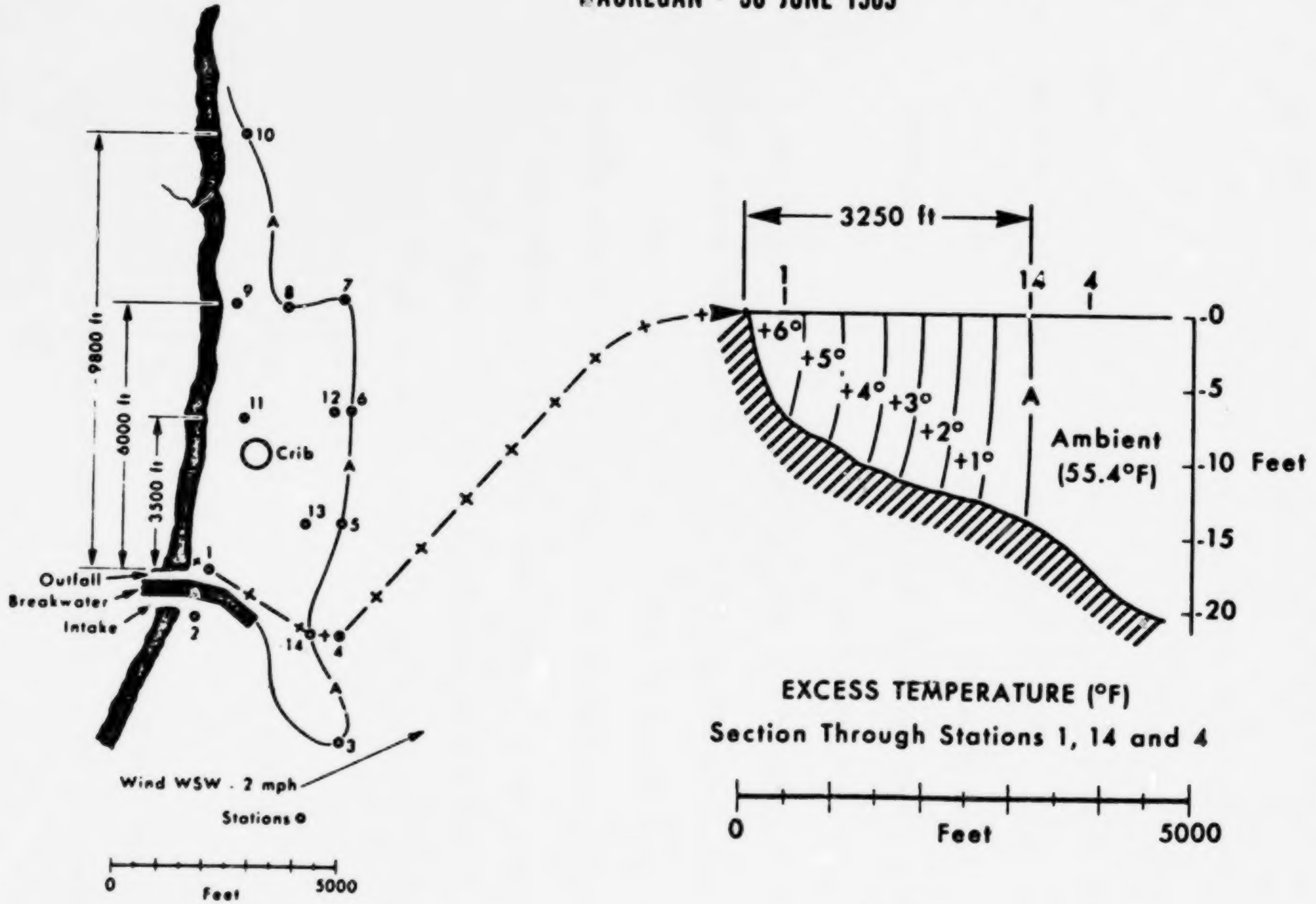
This 4,250 feet, along which benthic organisms would have been exposed to excess temperature is about 0.8 mile of the 1647 miles of Lake Michigan's shoreline. Furthermore, this distance lies mostly within a wave-swept zone, characteristic of Lake Michigan, in which benthic organisms are scarce because wave action produces shifting bottom and winnows away the detrital organic food materials of the benthos.

... Slide No. 3 (See P. 1054) ...

This is the first of four slides showing cross-sections of the plume. The orientation of this section is shown at the left by a line from shore through stations 1, 14, and 4.

Station 14 was isothermal at ambient temperature,

WAUKEGAN - 30 JUNE 1969



EXCESS TEMPERATURE (°F)
Section Through Stations 1, 14 and 4

J. C. Ayers

55.4 degrees F. The isotherms of excess temperature between Stations 14 and 1 are linear interpolations which may not be correctly placed for the actual conditions of the day, but which do accurately depict the limited lakeward extent of excess temperature.

... Slide No. 4 (See P. 1056) ...

Mr. Chairman and conferees, there is a typographical error in the last line. This should be 3,500 feet instead of 3,800.

This is the second transect of the plume at 4,250 feet of axial length or 3,500 feet along the beach.

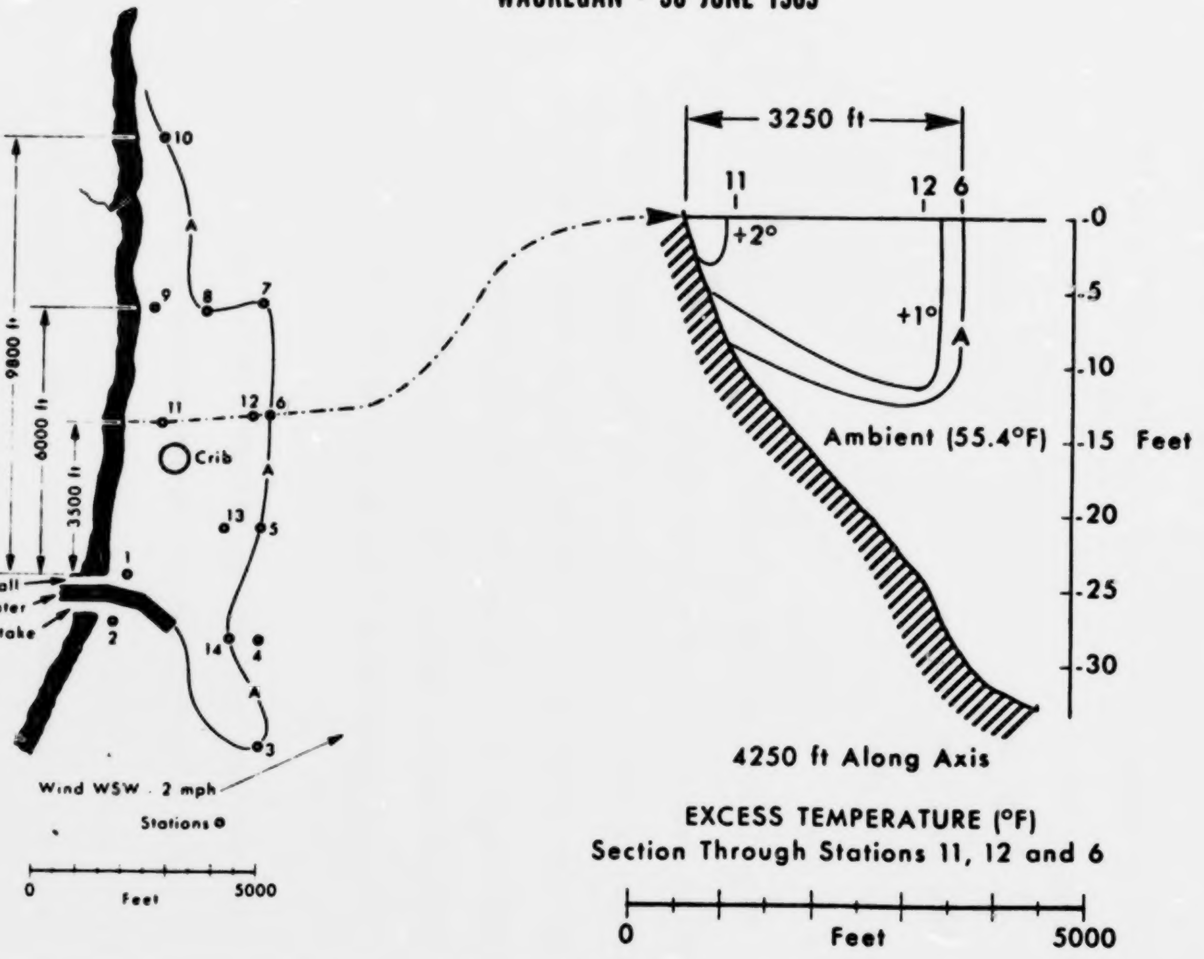
Here a section from shore through Stations 11, 12, and 6 shows the plume to be floating and to have a maximum excess temperature of a little more than 2 degrees F. All the temperatures above ambient are in the upper 12.5 feet of water, beneath which lies lake water of ambient temperature.

The maximum content of excess temperature in this section is inshore of Station 11, where somewhat over 2 degrees F. of excess temperature is in contact with the shore in only the very inshore upper 3 feet of water depth.

... Slide No. 5 (See P. 1057) ...

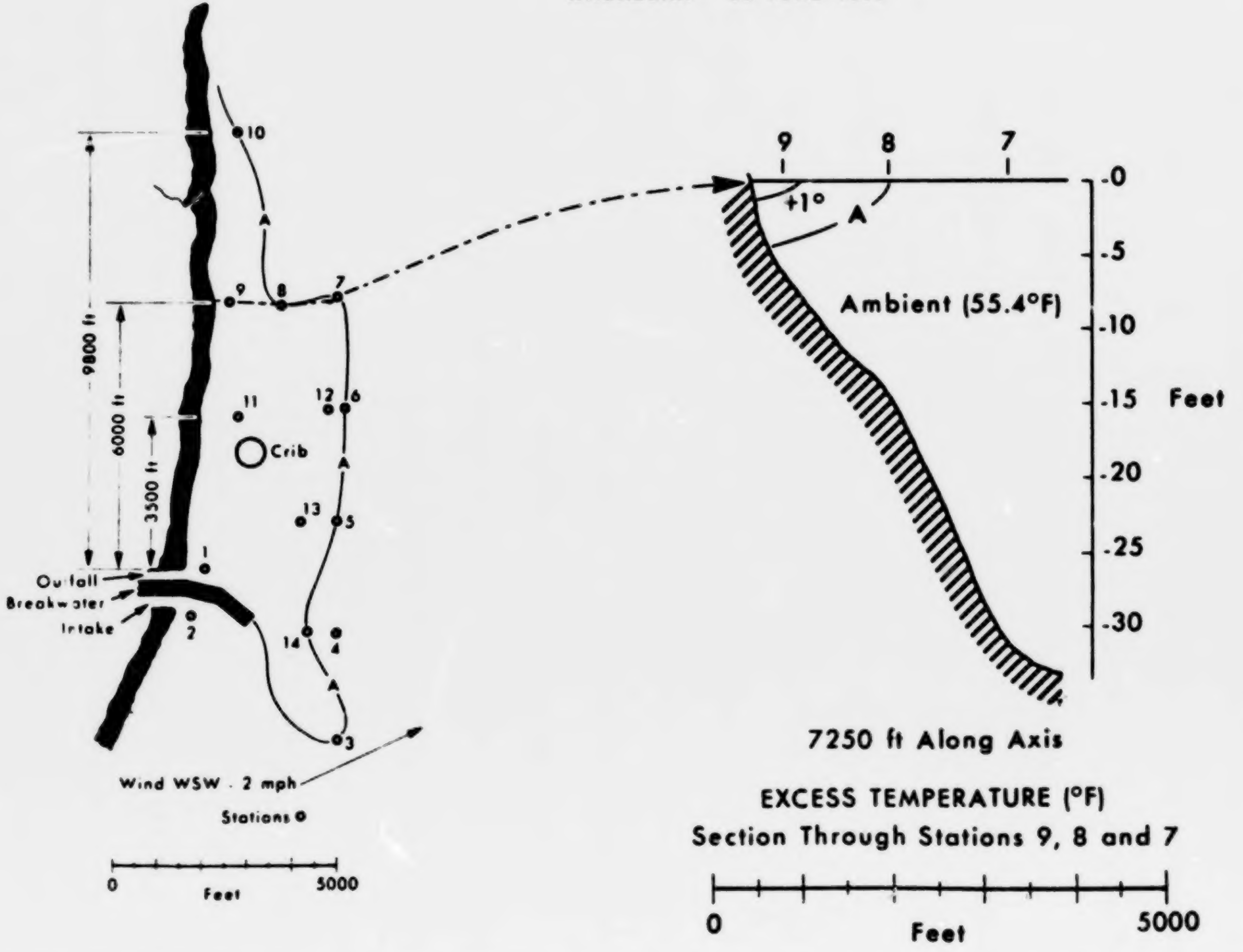
This is a cross-section of excess temperature through Stations 9, 8, and 7 at 7,250 feet along the plume

WAUKEGAN - 30 JUNE 1969



EXCESS TEMPERATURE (°F)
Section Through Stations 11, 12 and 6

WAUKEGAN · 30 JUNE 1969



axis or 6,000 feet along the beach. Ambient temperature is present on the surface at 1,250 feet off the beach and is present in the cross-section at 3.5 feet of depth. Above 3.5 feet of depth and against the shore the excess temperature barely exceeds 1 degree F. and is present in about one foot of depth.

In the Waukegan study just presented, the rapid diminishing of excess temperature in the surface water of the plume has been evident.

As a means of getting at a more representative measure of the decline in excess temperature along the axial length of generating plant plumes, a study of the distributions of loss of excess temperature along the axes of the best available plume surveys has been carried out.

In this study the initial amount of excess temperature has been that temperature observed at the mouth of the outfall structure where the survey boat could reach. It is emphasized that these initial excess temperatures are not plant Delta T's but that they are the excess temperatures with which the plume in the open lake commences. The computations consist of the initial excess temperature (IET) minus excess temperature remaining (ETR) at distance along the plume axis.

$$\frac{\text{IET-ETR}}{\text{IET}} \text{ X } 100 = \% \text{ excess temperature lost}$$

Length of the plume axis has been measured along the path (curved if necessary) of the plume to that point in contoured plots of surface temperature where 1 degree F. of remaining excess temperature occurred farthest away from the source.

In some cases a contour for the extent of initial excess temperature can be obtained, in such cases the percent of plume length has been computed for this zero percent loss of excess temperature. At other residuals of excess temperature, percent of excess temperature lost has been plotted against percent of plume length where the isotherm in question crossed the plume axis. All computations were stopped at 1 degree F. of remaining excess temperature because in most cases it was unclear how others had determined the beginning of ambient temperature.

Surveys of eight plant plumes of those available were adjudged adequate for the purposes of this study. The primary difficulty was lack of data on the initial excess temperature as defined above. Plant Delta T's are common, but actual temperatures at the beginnings of plumes in the open lake are scarce.

From the available adequate surveys the following plot of percent loss of excess surface temperature against percent of axial plume length has been prepared.

J. C. Ayers

... Slide No. 6 (See P. 1061) ...

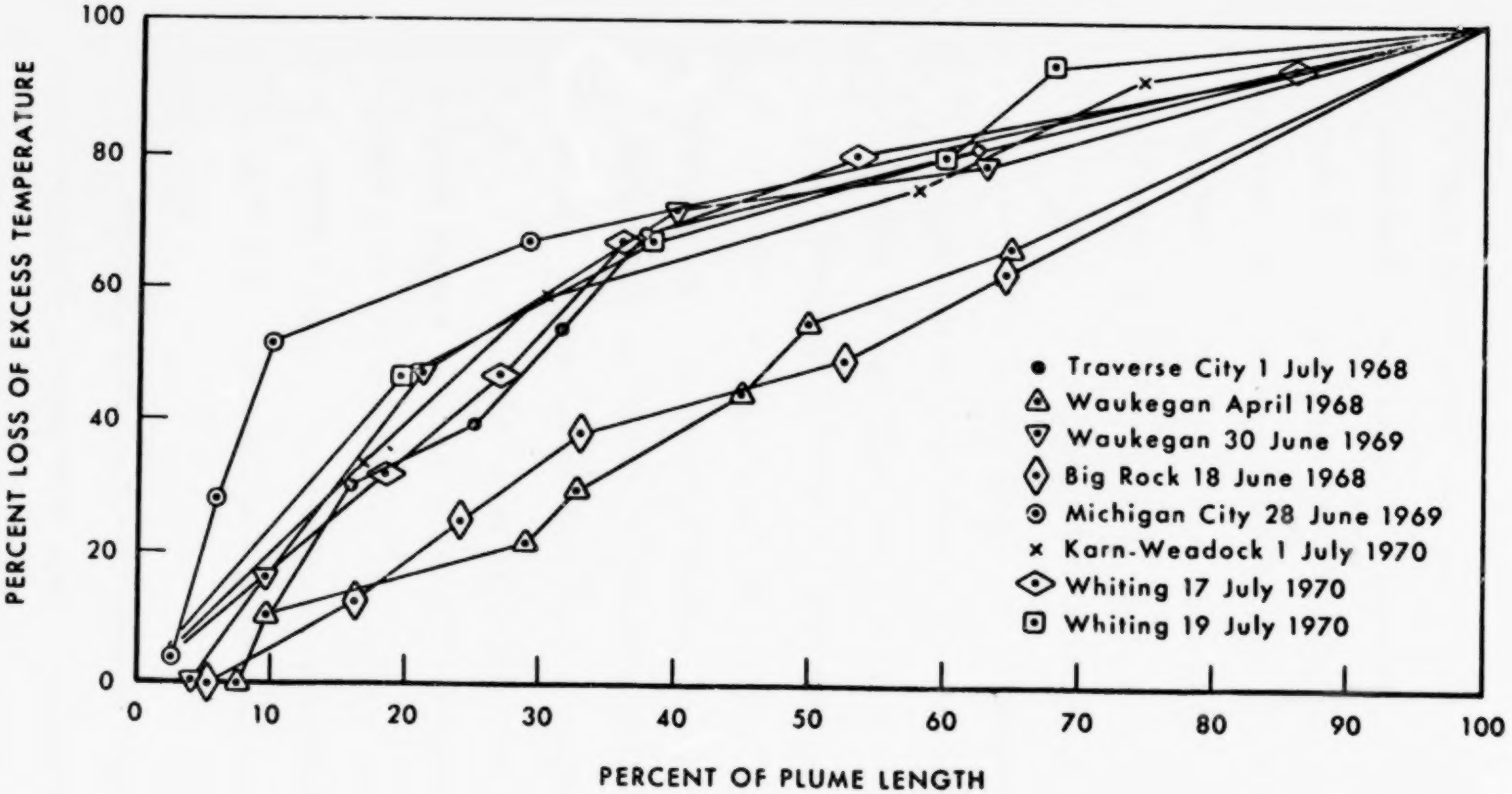
Five of the curves of loss of excess temperature against distance down the plume lie in a compact central band with two curves flatter and one much more curved.

Since the data include both large and small plants and different wind conditions, it appears to be possible to begin an approach to a generalized expression for loss of excess temperature in a natural plume in the Great Lakes. Further data and refinement of the generalized curve will be required, of course.

From the present data, it appears that 25 percent of the excess temperature is lost at about 13 percent of the axial plume length. Fifty percent of the excess temperature appears to be lost by 25 to 30 percent of the axis length along the plume. At about 60 percent of the plume length about 75 percent of the excess temperature has been lost.

The above considerations of loss of excess temperature in plumes of real waste heat in the real environment of the Great Lakes indicate rapid loss of excess temperature from the warmest parts of the plume with less rapid loss from the cooler parts.

I am going to depart from my text here for a moment.


PERCENT LOSS OF EXCESS TEMPERATURE
0
20
40
60
80
100
PERCENT OF PLUME LENGTH
0
10
20
30
40
50
60
70
80
90
100
● Traverse City 1 July 1968
△ Waukegan April 1968
▽ Waukegan 30 June 1969
◇ Big Rock 18 June 1968
⊙ Michigan City 28 June 1969
× Karn-Weadock 1 July 1970
◇ Whiting 17 July 1970
⊡ Whiting 19 July 1970

J. C. Ayers

This rapid loss of the heat takes place much more -- in much less time than I had previously realized. This spring down in the plume of the Bailly Plant at Burns Ditch, we were drafting bags of outfall water down the axis of the plume and sampling them when they reached ambient temperature. In several runs, these bags varied from 28 to 35 minutes to reach ambient temperature.

I will return to the text.

The primary thrust toward the establishment of thermal standards is the real fear among all of us that waste heat can be an augmenter of natural eutrophication processes. It is, however, proper to consider other factors in the nature of plumes that may bear upon whether waste heat in the real environment is apt to produce the undesirable biological effects that have been so abundantly demonstrated in laboratory tank experiments.

It is evident that the freedom of warmed discharge water to float upon the cooler receiving water is a condition not achieved in laboratory tank experiments where uniform temperature throughout the tank is a condition strived for.

It is also evident that test organisms are confined during laboratory tank experiments. This is another condition that does not pertain in warm-water plumes in the natural environment.

In plumes in nature the unconfined organisms are subject to daytime light and warming as well as nighttime cooling and darkness. Being unconfined, the organisms are free to use such powers of swimming as they possess. If they do not swim (the phytoplankton, for example) or if they are weakly-swimming (the zooplankton, for example) they drift with currents from place to place and from depth to depth and may even be transferred by mixing from water mass to water mass. None of these conditions are duplicated in laboratory tank experiments.

In brief, laboratory tank experiments utilize captive organisms under artificially controlled conditions, all of which is very different from conditions pertaining in nature.

The very circumstances that produce real warm-water plumes are virtually impossible to duplicate in the laboratory. In nature massive current capable of sweeping organisms into a plant is followed by mechanical mauling by pumps and then by abrupt addition of heat greater than that to which the organism is acclimatized, and these are in turn followed by release of the organisms into the open lake under conditions of rapidly slowing current and rapidly cooling water. Leaving out the possibility that the organisms might be subjected to fatal chlorination during their passage through the plant, the rapid sequence of physical changes alone would leave the organisms in a debilitated condition and little able to respond physiologically to the rapidly disappearing heat of the plume.

We genuinely believe that most of the present fear of release of waste heat to the environment stems from knowledge of the results of laboratory experiments without any accompanying information as to how waste heat behaves in nature, and I would comment here.

I suggest Friday, gentlemen, or maybe it will be Saturday, when you have the concerned conservationists before you, that you query the sources of their knowledge. I think you will find it is undigested results of laboratory studies.

Our studies of plumes of real waste heat in the real environment, and the similar studies of others whose data we have reviewed, do not reveal in or near real waste heat plumes the evil effects of heat that have been so confidently predicted from laboratory results.

We believe, as do others who have studied the problem in the field, that the physical behavior of warmed discharge water along with the physical conditions inherent in the production of a discharge plume act together in a manner that prevents the development of the predicted undesirable effects of heat. Our evidence indicates that the following circumstances prevent the development of the feared undesirable effects of heat:

1. Warmed water is less dense than cool water and floats on the cool water, giving off its heat directly or indirectly to the air, with little if any heat being actually incorporated into the aquatic environment. This is observed.

2. Plant intakes are usually in the same source water as the outfalls. The mere addition of heat for a short period of time cannot change the chemical characteristics of the water. This is observed.

3. The abrupt addition of heat in passage through a plant's condensers results in a temporary supersaturation of the plume water with oxygen. The supersaturation takes the form of microbubbles clinging to particulate matter, and the microbubbles redissolve as the water cools. It is observed that little or no decrease in dissolved oxygen is measured after passage through a plant.

4. Phytoplankton and zooplankton carried through a plant circulating water do indeed constitute a breeding stock that might respond to being in warm water by increasing their reproduction and producing noxious blooms. That

this breeding stock does not produce noxious blooms in the plume is observed. The reasons that blooms are not produced appear to be:

a. Mechanical mauling by pumps produces breakage and death of some of the plankters, particularly of zooplankton.

b. Occasional dosages of the circulating water with chlorine kill the breeding stocks of plankters passing through the plant at the time of dosing.

c. The abrupt addition of heat during a short-time passage through the condensers puts some of the plankton into a state of thermal shock from which recovery must be made before reproduction can be carried on.

d. Immediately after thermal shock is delivered in the condensers, the breeding stock of plankters is delivered into the discharge plume where water initially warm cools rapidly. Even with a breeding stock of plankters in good physiological condition, a regime of falling temperature is not conducive to heat-stimulated excess reproduction.

5. Changes in benthic populations near discharge plumes are minor, if observed at all. In a few instances benthos may have been washed out into deeper water by the current of the discharge water, but in general in Lake

Michigan the discharge of cooling water is into a natural wave-swept inshore zone where benthos is normally scarce or absent. Once the plume of discharge water begins to float, it is of course not in contact with the lake bottom and benthos are not affected by it.

6. Much is written and said about the disruption of fish physiology and behavior (and even the ability of fish to live) in or near plumes of warm water discharged from generating plants.

With few exceptions the things being written or said are extensions of laboratory experiments into open nature where they are applied to unconfined fish.

The observations of salmon behavior in the Columbia River are a living refutation of the criers of fish doom. In the Columbia River salmon have lived, migrated, and spawned in and through the Atomic Energy Commission's reservation where the Hanford reactors are located.

The water discharges from the Hanford reactors are much hotter than any plume that is extant in or contemplated for the Great Lakes, yet salmon have existed and increased their spawning at Hanford as dams have reduced their original spawning territory.

The Pacific Gas and Electric Company is

cooperating with the California Department of Fish and Game in studies of survival of small organisms that are deliberately passed through generating plants. To date they have reported that opossum shrimp, small king salmon, and small striped bass have been passed through Delta T's of 16 degrees F. and 18 degrees F. with a high rate of survival.

There is much speculation that local desirable species of fish will be replaced in plant plumes by coarse fish such as carp and suckers. It is true that local carp and suckers are attracted to the present generating plant plumes, but in so doing they leave available a wider ecological space for other species.

It is also true that desirable salmon and trout species are attracted to plumes of discharge water in spring, fall, and winter. Local fishermen in the vicinity of existing discharge plumes will testify to this.

In final summary, we have not yet been able to find evidence of adverse effects of generating plant cooling water upon Great Lakes aquatic ecology. The dire consequences of waste heat, so confidently predicted by persons who do not go into the field, are simply not being found by ourselves or others who seek them in real plumes in the real environment.

Mr. Chairman, I would like to make one more comment. I recall your memory to the thermal water picture which Mr. Polcyn showed and to the fact that you were just barely able to see the discharge of the Grand River in that massive display of swirling water in which there was a lot of heat, most of it apparently contributed by the sun.

I believe also that a part of the alarm over the discharge of waste heat is failure to realize how tremendous nature's applications of heat are in comparison to the size of heat from a generating plant.

Now, the outflow of the Grand is 500,000 gallons of water a minute, which is exactly the outflow expected for the Donald C. Cook Plant, and at the time that picture was taken, the Grand River was in the high teens warmer than the lake, so that its Delta T is approaching that of the future Cook Plant. Yet, in the picture, in comparison to the heat added by nature, the plume from Grand River was so insignificant it could be barely photographed.

MR. STEIN: Thank you.

Are there any comments or questions?

MR. PURDY: Dr. Ayers, you have discussed in detail your observations with respect to the effects of the pollution upon the ecology of the lake, but there is one other point that has not been mentioned so far in this conference, and that is the matter of the effect of the thermal pollution upon the ice barrier along the western shore of Lake Michigan. We do have severe erosion problems along this shoreline, and the ice barrier during the wintertime acts to protect this shoreline from erosion damage. Now, do you anticipate that there will be major destruction of this ice barrier and an acceleration of the shore erosion problem as a result of the thermal pollution?

DR. AYERS: I do not anticipate this. Last winter we flew the lake, photographing the discharges of all of the generating plants. In nearly every case -- in every case where we still found ice, there was heavy shore ice still on the shores right up to the edges of the discharge structure.

On the west shore, there was even ice in the — shore ice in the discharge channel of the Waukegan generating station.

MR. STEIN: Any other comments or questions?

MR. CURRIE: Yes.

MR. STEIN: Mr. Currie.

MR. CURRIE: I take it in regard to that last question, Dr. Ayers, you didn't investigate the effects on ice at all temperatures at all times, but only at a selected time when the temperature may have been low enough to overcome any effect which the thermal plume might have had. Is that correct?

DR. AYERS: No. We missed the coldest part of the winter, and we had -- in some parts of the lake -- primarily ice floes rather than solid ice.

Earlier photographs taken last winter at Waukegan in subzero conditions showed a very small melt hole in front of that plant and at Big Rock we could see the melt spot, and it was just small. Traverse City, with the submerged discharge plume, only a very small melt spot.

In all cases, where we still had ice, where the spring hadn't sufficiently progressed to the point where we lost the ice, we could see evidence of heavy buildup of shore ice.

MR. CURRIE: So you are prepared to say that this is essentially no problem?

DR. AYERS: I am convinced in my mind that there is no problem.

MR. CURRIE: Now, in your paper, you make a number of biological conclusions as to the effects of the heated water on the fish and other life in the lake, and yet it seems to me that the studies which you describe in here are primarily physical studies as to the dissipation of heat itself.

Where are the biological studies on which your biological conclusions are based?

DR. AYERS: A good part of them are my own, and I have also drawn upon the biological studies reported by others.

MR. CURRIE: Well, I think I for one would be helped if I could see the studies as well as your conclusions.

DR. AYERS: We have one or two sets of my reports available and others can be mailed to you later on.

MR. CURRIE: Now, I am interested in your analogy of the Grand River. I take it you are not suggesting that we ought to be willing to accept throughout the entire inshore zone of the lake the kind of biological conditions which are found around the mouth of the Grand River and as evidence of the kinds of conditions found there. I would refer you to a statement made by Dr. Bartsch at the first session of this conference with regard to both algal and sludgeworm populations.

DR. AYERS: I am aware of the conditions at the mouth of the Grand River. I was making the analogy of size of flow of a plant which would be drawing relatively clean water and putting back the same water.

MR. CURRIE: Thank you.

MR. STEIN: Are there any other questions?

MR. MAYO: Yes, I had a couple of questions, Mr. Chairman.

I was interested in your comment concerning a Hanford Plant on the Columbia River. It is my understanding that at the present time the only nuclear generating plant on the Columbia River has cooling towers for the specific purpose of minimizing or eliminating the input into the river from the tower.

DR. AYERS: I certainly didn't get that information from Nakatani's paper.

DR. TICHENOR: May I clarify a point?

MR. STEIN: Dr. Ayers, did you have another comment?

DR. AYERS: No.

DR. TICHENOR: My name is Bruce Tichenor. I am from the Corvallis Laboratory of the FWQA.

I would like just to clarify the point that there is a nuclear reactor at Hanford which in addition to producing plutonium also produces electric power. This reactor was not designed for the production of power, but they are using the waste heat from the reactor to produce power. However, the first commercial nuclear powerplants constructed by a utility -- the Portland General Electric

Company -- is in the final planning stages at the Trojan site, near Portland or on the Columbia River, and they do plan to use cooling towers.

MR. STEIN: Well, in order to round this out, I think the facts are that Washington and Oregon have essentially adopted the no-temperature rise for powerplants in both States in their water quality standards now.

MR. MAYO: I get the impression, Dr. Ayers, that you differ somewhat from Dr. Raney in terms of the opportunity for either mortality or damage or mauling of organisms as they pass through the condenser stage. I got the impression, I think, from Dr. Raney yesterday that there was a pretty rosy sort of a picture -- that things slid through and came out without any significant damage. I get the impression from your observations that there could be a rather substantial amount of damage.

DR. AYERS: I don't think it is a substantial or significant damage, but we frequently find 20 percent of the zooplankters are broken.

MR. STEIN: Well, I have just one real general question here, Dr. Ayers. You heard the first paper that alluded to this combination of factors that I talked about I believe, yesterday -- at least two of them -- that is, when you get the water in, you have this bruising and mauling, and occasional shots of chlorine, which I understand doesn't do the organisms any good.

DR. AYERS: No.

MR. STEIN: Then, aside from the heat, you have the combination of the heat and the question that Mr. Purdy talked about of the velocity of the water, whatever temperature it is, as well as the fact you are taking in a lot of water and displacing it.

Now, as a conservationist, what would your recommendation to this panel be? Do you think we should go along with this once-through cooling method, which is not to cool the water but to cool the condensers from the plant and not beneficial to the water? As far as I am concerned, I have heard no one here from the power companies propose a water-cooling device just to cool the water.

As a conservationist, do you propose that we go along with this as a future approach to protect Lake Michigan, then just wait and see if we have any trouble later? Or should we do something to possibly restrict it? I think your advice on this would be very useful.

DR. AYERS: As a conservationist, and after the years that I have put in studying the matter, it seems to me a practical solution would be to let the present building plans come through. We need not only the experience on this, we need to actually find out if we can find any damage there. All of the evidence that I can lay hands on today — and mine seems to match other people's — is that we are not finding the evil effects, and that very likely once-through cooling even on a bigger scale, given judicious siting, no overlap of spawning streams, and several other obvious things, I believe that our present evidence indicates that we could try these three, four, or five big plants, get some real big plant knowledge and they have all agreed to modify if we find anything.

MR. STEIN: Well, I am not sure they have the site. This is the point I am getting at, and I would like to explore this with you. If you do this now — and we have heard testimony that once anything is in the planning stage, don't fool with it — now, obviously, no industry, including the power industry, can stop tomorrow. They are going to plan; they are going to go forward with this operation. If we adopt that, how far down the road are we committed if we decide to make a modification . If we are confronted with the notion that once they have selected the site — and I know you modified your statement with judicious site selection — but once they have selected the site and they have started the plant, and then the notion is this can't be changed, as we have heard, where does this leave us? I am trying to work out with you an approach or get a recommendation from you on how we are going to protect the lake. I recognize your scientific concern. But as an operating agency, we have to make the judgment. Hopefully industry will agree with us on how we proceed. I am not sure -- I think I understand you correctly -- from the scientific point of view, you would like it if we could freeze everything, and you could check this out in actual conditions in the lake. Now, you can come up with a judgment, but the world has to move. We can't freeze, so how do we move? How would you suggest the conferees move from here?

DR. AYERS: I would suggest the setting of an interim set of standards such that the building plants could live with for 5 to 10 years, and use for this the experience and guidance of the State people who not only know the problems locally, who have to do the enforcement, who know what is practical for them. If these could be a compromise interim thing, that would be the best I could suggest.

MR. STEIN: Thank you, sir.

Are there any other comments or questions?

MR. PURDY: A comment, Mr. Stein, with respect to your statement, and as a State in which two of the large nuclear facilities are now being constructed, I don't believe that we are ready to accept the fact that the existing facilities cannot be modified should an injury result. If the studies that are under way show an injury, we feel that these necessary modifications must be made.

Now, I hope that I am interpreting the statements of the industry correctly that if you had to shut the facility down immediately and could not operate it until the modifications had been made, that then this would cause a serious interruption in the plant.

From the standpoint of the statement of American Electric Power this morning, I do not interpret this that they cannot build a wet cooling tower, that if a wet cooling tower is built, there will be certain other undesirable side effects from this, from the standpoint of aesthetics in that particular area, but that it can be put in at a cost and that, if necessary, it will be put in, and this is the position that we take on this.

MR. STEIN: Well, I hope that -- that is a possible position. Again, having been through some of these, Mr. Purdy, when you talk about an alternative in this business, shutting down the plant, I think you are going to find in the face of it, it isn't a very realistic alternative, in view of the power needs we have now.

Now, I just put this out without saying that anything is needed. But the question, again, that I think has to be determined is are you going to have, say, either a closed loop system, wet cooling towers, dry cooling towers, lagoons, what-have-you, and presumably you are going to have to consider that the site is available for these contingencies, and you are going to have to be prepared to go with that? You are not going to be blocked because of congestion, highways, drift, meteorological conditions, roads, or airports?

Now, the point is, I think, if we adopt what I understand your suggestion to be -- that we are not precluded by the very physical and economical conditions and the need for power in exercising options if you feel these options are important.

MR. PURDY: That is correct, and in addition for those plants that are now under construction, we are requiring that the alternatives now be selected, so that if they are necessary, there will be no lag in the design.

MR. STEIN: Yes, for some of the plants here the companies may want to answer this later. In the testimony we have heard concerning the existing Zion plant, for example, we already have heard that the company feels that none of these remedial facilities are feasible on the site they have selected. In other words, the options already are stopped. Possibly your only alternative would be to shut the plant down, and the reason those plants were built was the crying need for power, and this would ruin the whole ball game if we did that.

Now, this is the situation, I think, and we all have to work with it -- that the conferees confine themselves to that. I can appreciate Dr. Raney's approaches and doubts, but I know he approaches this with scientific inquiry.

But if remedial facilities are called for we must be able to put them in and not just block all our avenues.

DR. AYERS: If damage is proven, we will need corrective measures.

MR. DUMELLE: I have two questions, Dr. Ayers. On your June 30, 1969, study of Waukegan, you measured the ambient temperature and gave it as 55.4 degrees Fahrenheit, and I recall that earlier in the conference some of the people testifying stated that it was very difficult to measure the ambient temperature of the lake because of local hotspots or coldspots, and I wondered if you could comment on how precise a measure is that ambient temperature that you recorded, or any other enforcement type measurement.

DR. AYERS: The determination of ambient can really drive you crazy. I have some surveys which I can only partly use because I cannot determine ambient.

In my survey of Waukegan, I caught the area in a very uniform condition, where at an intake south of the breakwaters, the intake temperature was 55.4, and that I took as ambient, and I found it all of the way around the edges of the plume. I wanted to look at what was happening to the added heat, so for this type of thing I took the intake temperature.

MR. DUMELLE: What would be a range of precision, within 3 degrees or within 1 degree, or within 5, on determining ambient temperature?

DR. AYERS: In this case, I was able to get 1. Usually I have to be satisfied with 2.

MR. DUMELLE: Two degrees?

DR. AYERS: Sometimes even 3.

MR. DUMELLE: Or 3. Thank you.

The second question is: I would be very much interested in whether you fully agree or disagree or anything in between with the Federal thesis of the inshore waters acting in effect as a separate part of the lake, and comprising only 4 percent of the volume, and I think that is a very important part of the Federal case.

DR. AYERS: I am afraid that I don't agree very much with their thesis. As I see the inshore bar and have seen it for several years, Pritchard's computations of shear mixing along the bar are evident. They were even evident in the slide -- those great swirls on the outside. So, in general, I can accept rather little of their conclusions.

MR. DUMELLE: For the interest of the conferees, I have taken Dr. Pritchard's interchange figure, 1,480,000 c.f.s., as passing through this bar or barrier. If you relate that to the 47.6 cubic miles contained in inshore waters you get a turnover rate of 43 days. In other words, every 43 days the inshore waters are changed.

Now, that to me is a significantly long period, and would indicate, as I would see it, that this is acting as a separate body of water. If you are only changing 2-1/2 percent of the water every day, reciprocal of 43 days, it seems to me you are dealing essentially with the same bulk of water.

DR. AYERS: I think, in countercomment, that it is equally important that our measurements of total dissolved solids do not indicate drastic rises in Delta T's during the time when the thermal water is present.

MR. STEIN: I think possibly, gentlemen, what we have just heard here illustrates the problem that we have. Of course, Dr. Pritchard has left, which possibly is unfortunate. But as I understood him, he dealt with just heat. He said there was no evidence of damage and as a matter of fact in his opinion heat might be good for the lake. That might lead to the conclusion we should encourage discharges.

You have found no damage, in a sense, and you have a latency attitude with an interim kind of proposal. Mr. Dumelle evidently thinks there is pretty good evidence of damage now, but I think you might adduce from that that we might have some restrictions at the present time.

Now, I think, given the same body of evidence, and, I am sure, very able scientific people have this spectrum of use -- again you have to recognize that the panel, in dealing with the lake, is going to have to exercise reasonable prudence and caution, because that lake really is not a thing we can toy with as an experimental body of water to find out what happens. We must be reasonably sure it is safe in dealing with it.

Mr. Barber.

MR. BARBER: My name is Yates Barber. I am with the U. S. Bureau of Sport Fisheries and Wildlife, Washington, D. C.

Mr. Chairman, I would like to question Dr. Ayers on certain points that are in his paper. On pages 9, 10, and 11, you treat the matter that breakage of plankters passing through a plant would reduce the breeding stock, which might otherwise result in eutrophication due to increased heat.

Is this generally correct, sir?

DR. AYERS: Yes.

MR. BARBER: Is this work of determining the breakages -- is this based on actual field experience and research?

DR. AYERS: Yes, we have been doing this quite awhile.

MR. BARBER: On Lake Michigan, sir?

DR. AYERS: Yes, sir.

MR. BARBER: Does this include the work done by I believe, a Mr. Krezoski, one of your students, I believe?

DR. AYERS: He was in on the beginning of our technique, when we were having some trouble.

MR. STEIN: May I suggest that you both speak a little louder. I know both of you can hear each other and the secretary can hear you, but I am not sure about the rest of the people.

MR. BARBER: Fine.

I note that you conclude, as a result of your work, that about 20 percent of certain types of plankters might suffer breakage. You have determined this?

DR. AYERS: They seem to be the large zooplankters.

MR. BARBER: Right, sir.

Now, I believe you also state there -- and let me read this: "the rapid sequence of physical changes alone would leave the organisms in a debilitated condition and little able to respond physiologically to the rapidly disappearing heat of the plume."

But, I take it that the other 80 percent or all of the other surviving organisms even though they came through do tend to show damage from the experience, and that presumably they would not -- as we contend -- show an accelerated breeding rate because of the increased temperature.

DR. AYERS: According to our observations and some that Mihursky at Maryland has made, he has demonstrated loss of fuller photo synthetic activity. We have found some actual cell count in oceans.

I believe that my thesis is basically the reason why we do not find noxious blooms of blue-greens or greens in the plume.

MR. BARBER: Now, I take it from another statement here that is in your paper that you contend that if you could inoculate this plume again with undamaged organisms that their physiology, their reproduction might be controlled by the fact that the heat was in declining phase. Is this right, sir?

DR. AYERS: That is right.

MR. BARBER: How long would this effect last? I mean what is the temperature range over which this would prevail, and what time factors are involved?

DR. AYERS: I think the largest temperature range that I have seen yet is 12 degrees of excess temperature, as I define it, and while very few people have made float measurements down the length of the plume, I think my measurement of roughly a half hour to ambient at Bailly is indicative of the speed with which these plumes die away.

MR. BARBER: But at what temperatures would this effect of physiological restriction cease to function? Would this cease at only, say, 18 to 12 degrees, or would it have effects from these temperatures on down?

DR. AYERS: You mean in the case of our re-inoculating?

MR. BARBER: Yes, sir.

DR. AYERS: Oh, that would continue until ambient was reached, and down to a degree or half a degree effect; as long as it is declining, it would be not conducive to excess reproduction.

MR. BARBER: I see.

Well, yesterday, Dr. Pritchard presented the hypothesis, based on his model, that the best way to handle heat would be to inject it at a very high velocity so that it would entrain vast quantities of other lake water, resulting in a small high-temperature zone, but a very, very, very large zone of quite low temperature, so that there would be a maximum surface exposure.

Now, in a case of this sort, would not the lake organisms involved in this mixing process, be in effect unaffected entrained organisms that did not go through the plant system; and would this not actually involve many times the volume of water actually sent through the plant? Is this correct, sir?

DR. AYERS: Yes.

MR. BARBER: Right, sir.

DR. AYERS: But they would still receive a dimension temperature relationship.

MR. BARBER: Right, and here the eutrophication process that we fear would be induced.

Now, let me ask you this: If this volume of water -- that we have predicted might be as much as 4.4 percent of the inshore area and mind you this is only what passes through the pumps, not what is entrained outside of the plant -- and if the physiology of these organisms would be affected, and if we assumed that we lost virtually all of the organisms or their effective reproduction for this 4.4 percent that goes through the pumps every day, and knowing that many times this volume would be entrained and subjected to a declining temperature down to the 1 degree that Dr. Pritchard indicated would involve at least a possible 11-hour exposure, is it not true that tampering in these ways with water in this volume and in these shallow areas, that we might well be tampering with the total productivity of this lake?

DR. AYERS: No, I don't believe it. I think you deal with a very minute part of the population, and even though I didn't make a point of it, the organisms which I talked about as being in thermal shock are expected to recover.

MR. BARBER: They are expected to recover?

DR. AYERS: Yes.

MR. BARBER: Thank you very much.

MR. STEIN: Thank you.

Are there any other people who wish to ask questions or make a comment at this time?

If not, I would like to thank you very much, Dr. Ayers. I think you made an excellent contribution to the conference, and I would also like to thank American Electric for inviting you or making you available.

DR. AYERS: Thank you.

MR. STEIN: Off the record.

(Discussion off the record.)

MR. STEIN: We will get back on the record.

I think, Mr. Bane, it is about 12:00 o'clock, and I think we may recess for lunch now. Do you want to say something first?

MR. BANE: No, that is perfectly all right. We would like to resume after lunch with the Commonwealth Edison case. I would just like to say with respect to Mr. Dumelle's remarks about the 43-day turnover, which he derives from Dr. Pritchard's calculation -- Dr. Pritchard, of course, testified before the Illinois Pollution Control Board and is going to be made available at the request of the hearing officer at hearings on November 5 and 6 for cross examination. So that I would suggest that before Mr. Dumelle or anybody else reaches a final answer on that 43-day matter, that he will wait and explore it at his own board's hearings early in November.

MR. STEIN: I can understand your view. I just wish Dr. Pritchard had been available to us here because he did make some quite definite and extensive remarks, but I guess that is just one of these things that we have to go along with.

MR. BANE: Well, he was available yesterday, of course.

MR. STEIN: Well, not at the end when we asked for him.

In other words, if anyone is going to leave, we should first give these people an opportunity to ask questions after that person has finished his presentation. We are doing that from now on. I think this was unfortunate indeed, since there were several questions on a presentation we assumed they would be available and they weren't here.

MR. PETERSEN: Mr. Chairman, I would just like to suggest that when calculations are accepted from the floor as to such matters as the turnover, that it would be helpful to those of us who are here to have that person later testify as to those matters, so we have a chance to question him pertaining to such calculations and other theories.

MR. STEIN: Is Mr. Dumelle here?

Do you want to speak for him, Mr. Currie? He is never very bashful in my experience.

MR. CURRIE: I am sure Mr. Dumelle would be willing to answer the question.

MR. STEIN: Thank you.

All right. We will stand recessed until 1:30.

(Noon recess.)

- - -

Murray Stein

AFTERNOON SESSION

- - -

MR. STEIN: Let's reconvene.

We are going to continue with the power company presentations. I note several of the other State representatives have some other people here that they feel they might want to get on today.

I would like to do two things. I wonder, Mr. Bane, if you can give me an estimate of how long you think your presentation is going to be?

MR. BANE: We have a final two witnesses and I would estimate without the time required for their cross examination they would take about an hour.

MR. STEIN: About an hour?

MR. BANE: Yes, sir, yes.

MR. STEIN: I would again ask that -- I know Michigan, Wisconsin -- I am not sure that the Attorney General of Illinois wants to make a statement -- but I think we should get that lined up as soon as possible to put everyone on. The way it looks to me, we will get everyone today who has to get on.

Mr. Bane, would you continue?

MR. BANE: Yes, sir, the first of our final two witnesses, Mr. O. D. Butler, Assistant Vice

President, will discuss alternative cooling possibilities at Zion.

STATEMENT OF O. D. BUTLER,
ASSISTANT VICE PRESIDENT,
COMMONWEALTH EDISON COMPANY,
CHICAGO, ILLINOIS

MR. BUTLER: Mr. Chairman, members of the conference, ladies and gentlemen. My name is O. D. Butler, and I am Assistant Vice President of Commonwealth Edison Company in the area of engineering.

Commonwealth Edison has devoted careful study to its proposal to use Lake Michigan water to provide cooling capacity at the company's generating stations located at Zion. We are convinced that in proposing to use Lake Michigan water we have selected the method of cooling which is the most desirable among the methods which we might reasonably employ at Zion.

Last Friday afternoon the Federal Water Quality Administration released a report entitled "Feasibility of Alternative Means of Cooling for Thermal Powerplants Near Lake Michigan." This report is significant to the deliberations of this conference and it seems appropriate, therefore, that we offer a preliminary evaluation of that report in terms of our plans at Zion.

The report was prepared by scientific organizations who exhibit competence in their field. Although they are not experienced powerplant designers, it is obvious that they have reviewed much of the published literature and have conversed with a number of persons in the field. Basically, the authors of the report have gone to the manufacturers of cooling towers and spray-pond equipment to find out whether their equipment would be suitable for powerplant use in the Great Lakes area. Not surprisingly, they have concluded that such equipment is feasible when properly applied at properly-selected locations.

We do not propose now to debate the detailed basis of the many items of data and computations that the report contains. However, because it is often tempting to sweep aside the qualifying clauses and remember only the broad conclusions, I think it is very important that some of the qualifying clauses to the conclusion of this report be brought to your attention and kept firmly in mind.

First, the report makes it clear that "no attempt is made to optimize any particular plant or site." (FWQA Report, P. I-1) The report recognizes that these cooling devices do have the potential for producing undesirable environmental effects but that these potential problems can be avoided or alleviated through proper site selection and engineering design -- an approach which is very similar to Commonwealth Edison's approach to once-through cooling designs. The report also points out that careful pre-site selection surveys should eliminate sites which have a high potential for fog or drift problems. The authors of the report suggest that such problems should normally be prevented by siting a cooling tower as far from highways and airports as possible. They also recommend that the tower be located so it is down wind from the point of interest during periods of low temperature and high humidity. Again, our studies of this problem confirm these observations and recommendations.

These observations and recommendations are highly significant in terms of our Zion site because the site would not permit compliance with them. In fact, considering the landscape of the State of Illinois along the Lake Michigan shore from the Wisconsin border to the Indiana border, I believe that there is not a single site that would meet the qualifications, just reviewed, which are a part of the basis for the conclusions of the report.

I think two significant facts, each of them brought out in this report, should be kept in mind in conjunction with the use of the report's conclusion. First is the fact that the conclusion does not apply to any particular plant or site. The second fact is that the cost estimates and resultant conclusions of feasibility are not based on back fit of an existing plant or of a plant well advanced in construction. The report makes this very clear. But as I have said, it is tempting to remember only the conclusion.

I think it would be worthwhile to explain the inapplicability of the cost estimates and site requirements of the FWQA report to the Commonwealth Edison's Zion plant on Lake Michigan in the State of Illinois. The Zion site has been a planned electric generating station site since its purchase in 1955. Prominent signs on the property have displayed this fact through most of those intervening years. The Zion site location was particularly advantageous because of its closeness to Chicago, the principal load center in northern Illinois. Of further importance was its location in relation to other generating units. New generating units prior to Zion were located in the western and southwestern area of the

O. D. Butler

Commonwealth Edison system. Additional generation in the northern area of the system would improve system reliability because, as generation and load are balanced by areas, the north-south bulk transmission becomes more available to transmit power flow.

Detailed design of the Zion facilities was begun on a full-scale basis in the fall of 1966, and major equipment purchases were made in the spring of 1967. Site work began in the fall of 1967, and construction has been proceeding at a rapid pace since the spring of 1968. To date more than 200,000 cubic yards of reinforced concrete is in place. This represents more than 80 percent of the structural work. More particularly, it means that the dimensions of the condensing equipment have been fixed in concrete and in fact the main condenser for the first unit is well along in erection and welding. The second unit is ready for shipment to the site. The design we adopted for cooling was considered to be the best plan with respect to impact on the environment. The design met and still meets all thermal and other governing regulations, and we still believe sincerely that it is the best design for the site.

The authors of the FWQA report on the feasibility of alternate means of cooling do not address themselves to the problems of adapting their alternate plans to a plant in such a stage of construction. In fact, they assume that the means of cooling will be decided before design begins and that the size, configuration and location of the equipment will be optimized, or nearly so, for the cooling means selected. To illustrate the significance of this assumption with respect to an assumption that the alternate cooling means might be applied at Zion, I would like to briefly mention ten significant considerations not evaluated in the FWQA report:

1) Our studies show that the cost of applying wet or dry cooling towers at the present stage of construction of Zion station are in the order of five to six times the cost estimates in the report.

Our preliminary engineering estimates indicate that dry natural draft towers would cost more than $200 million in capital cost, capacity loss and additional fuel consumed due to poorer plant efficiency. Our estimates use the plant cost in dollars per kilowatt as the plant is now proposed to be constructed in the evaluation of cost of lost capacity. Even for a new plant where construction has not begun the estimated costs in the report are below price estimates that have been made to us by some of the same manufacturers whose data was quoted in the report. It appears that adequate consideration by the authors many not have been given to items that are not normally included in the tower suppliers' package, such as structures, piping, electrical services, controls, realistic labor rates, escalation, poorer efficiency and top charges.

2) We are in a relatively high incidence tornado area, where extremely high winds may jeopardize cooling tower structures.

3) The aesthetic degradation of a lakefront plant by the addition of massive cooling towers of either the wet or dry type was ignored in the report. Natural draft towers are almost certain to be considered undesirable additions to the aesthetics of the Lake Michigan landscape. I assume the authors of the report ignored this consideration because their advice is to eliminate plant sites from consideration where such a problem in cooling tower application may exist.

4) The noise problem associated with the fans in mechanical draft towers was also ignored, again perhaps for the same reason. This problem would be a very serious one at Zion and other existing sites, due to the limited size of the sites and the proximity of populous areas.

5) The Zion site is approximately 3 miles from

the Waukegan Memorial airport. Our request to construct a 400-foot high meteorological tower was reduced to 445* feet by the Federal Aviation Administration. The FWQA report assumes that tower heights will be on the order of 500 feet for a unit a little more than half the size of the Zion unit. This difference will have a profound effect upon cost, and more importantly, upon plume behavior. Marshy land to westward of the north shore towns already produces a bad fogging condition. Low altitude vapor plumes from cooling towers may seriously worsen this condition. We have had photographs reproduced which show plume effects at the TVA's Paradise Station in Kentucky and at the Keystone Station operated by the Pennsylvania Electric Company in western Pennsylvania. I believe those are filed with the report as Exhibit B. We will file copies of those photographs with this testimony. (See Pp. 1111a-1111c)

Our consultant, Dr. G. E. McVehil of Sierra Research Corporation, has performed some studies of the plume behavior and meteorological effects of cooling towers that reasonably could be built at the Zion site. His preliminary findings are attached as Exhibit A to this testimony. (See Pp. 1106-1110)

Dr. McVehil's findings indicate that cooling

# Should read 245, not 445. (see p. 1112.)

towers at Zion would create significant problems due to fog, icing and increased cloud cover, which would be undesirable in a metropolitan area. The report does not seem to recognize the significance of the shore line of a large body of water on the environmental effects caused by the alternate cooling means. Chicagoans frequently hear of the "lake effect." This phenomenon will have an important bearing on the acceptability of cooling towers, as is pointed out in Exhibit A.

6) The report recognizes the possibility that removing water from Lake Michigan, not to be returned, may constitute an undesirable diversion. For a plant located in the State of Illinois this is an important consideration.

7) In the case of very large dry towers, such as would be required at Zion, knowledgeable people in the industry have been concerned with their effect on the meteorological conditions in the area. No towers even approaching this magnitude have ever been undertaken, so there is no experience to rely on. I think Dr. Robert Jaske of Pacific Northwest Laboratories expressed these concerns very well in a paper presented in August 1968, to the ASCE Conference on Research Needs as follows:

"In the case of the dry, nonevaporative systems, serious consideration must be accorded to the induced circulation of the immense air plumes which would rise above the installation. On relatively quiet days, it has been estimated that such dry towers could induce sufficient vertical circulation to produce cumulus clouds of extensive magnitude over the release point. The resulting opportunities for involvement in weather are not inconsiderable and remain as one of the significant research areas for the future." Dr. McVehil has pointed out that changes in precipitation and other weather effects are found down wind of large cities. These are believed to be manmade effects caused, at least in part, by heat from the city. The implications of a possible large number of dry cooling units some time in the future deserve serious consideration.

8) Another consideration with regard to dry towers not recognized in the report is that design and cost data must be extrapolated from much smaller installations. Insofar as we have been able to determine, the largest operating Heller cycle dry tower in the world is of 150 MW size, 1/14 the size of Zion. If we were to construct mechanical draft dry cooling towers, preliminary investigations indicate that we would need to construct two such towers, each roughly more than a block wide,

nearly a half-mile long and taller than a five-story building.

Additionally, dry type cooling tower installations normally employ an entirely different condenser cooling cycle philosophy, and the steam turbine would be designed for back pressures impossible with the standard design at Zion. To understand the differences in the condenser cooling cycle, it is necessary to review the equipment involved. The Zion cycle utilizes a tube type surface condenser in which steam is condensed on the outside surface of the tubes by circulating lake water within the tubes. A dry cycle on the other hand, utilizes a direct contact condenser in which steam is condensed by intimate direct contact with cooled water returned from the tower. Conventional turbine generators operate with vacuums at their exhaust ends in the range of 1 to 3-1/2 in. Hg. Abs. The manufacturers' designs are for a maximum of 5 to 5-1/2 in. Hg. The vacuum is directly related to the cooling water temperature. With a dry cooling tower system, optimum cycles operate at considerably higher pressures because the dry tower is simply unable to provide the condensing water at the cool temperatures available with wet systems. In summary, neither the condensers nor the turbine-generators at Zion are compatible with dry cooling towers.

9) A specific cost omission which is admitted in the report is land preparation and construction work associated with cooling ponds. This is such a significant cost factor that this part of the study is of limited value. Insofar as a cooling pond at Zion is concerned, it is simply not a feasible alternative because adequate land is not available.

10) At this stage of construction of our Zion station, adoption of one of the alternate cooling means treated in the report would seriously delay completion of construction and operation of the plant. The Zion units represent an integral part of our planning to meet our system load requirements in the next several years. In the simplest terms, a delay would mean that we will not be able to provide the dependable power reserves which we have provided until now and which our plans at Zion are intended to enable us to continue. Of course, a delay would be expensive in terms of additional costs generated; for example, by the necessity to continue to pay interest on an investment which is not earning a return -- but a delay would be expensive in broader terms as well, for in a very real sense it would mean relinquishing the certainty that we will be able to provide reliable electric

service as we have done in the past.

In conclusion, the report does not say that cooling towers, wet or dry, are feasible at every site and it does not say that it is feasible or practicable to back fit a plant with these cooling means. Commonwealth Edison has devoted careful studies to its proposal to use Lake Michigan to provide cooling at the Zion site. Our studies convince us that our use of Lake Michigan with the plan for intake and discharge that has been developed will not exert any adverse influence upon the ecological balance of the lake. We are by no means opposed to cooling towers or cooling ponds as a general matter. But we believe that the cooling method we have selected at Zion represents the best choice among the methods which have been considered by us and by the report of the Federal Water Quality Administration and is the choice which is most desirable from the standpoint of its impact upon the total environment.

Exhibit A

1106

PRELIMINARY REPORT

ENVIRONMENTAL EFFECT OF COOLING TOWERS AT ZION NUCLEAR GENERATING STATION

Prepared For:

Commonwealth Edison Company
Chicago, Illinois

22 September 1970

Prepared By:

George E. Mc Vehil

Sierra Research Corporation
Environmental Systems Group
Boulder, Colorado

I Introduction

Sierra Research Corporation is conducting an analysis of possible environmental effects of alternative cooling techniques proposed for the Zion nuclear generating station. This analysis is primarily directed toward potential problems of fog and icing in connection with evaporative cooling towers. The present brief report presents preliminary conclusions of the study, which is still in progress.

II Significant Meteorological Factors at Zion

The Lake Michigan area has several features that tend to create unique problems for cooling tower operation. These are all related in some way to the presence of the Lake.

The Lake serves as an additional source of water vapor for the air, resulting in somewhat higher humidities than average for the upper midwest. The effect is, of course, greatest near the lake shore. A combination of factors conducive to cooling tower fog occurs with on-shore winds in spring and summer. Air carried inland is both moist and cool, giving a stable situation with weak mixing and little additional water required to produce saturation. Indeed, natural fog at times occurs in these situations.

A further important effect, directly related to that just described, is the existence of the "lake-breeze circulation." This local atmospheric circulation, driven by the temperature difference between land and lake, takes the form of lake air blowing inland near the ground, rising at a distance 5 - 15 miles inland, and returning toward the lake at altitudes of several thousand feet. The lake breeze occurs during the day when the land is warm, and reverses direction at night to become a land breeze.

The potential hazard in the lake breeze, which occurs frequently along Lake Michigan during the spring and summer, is that since air velocities are low and the circulation essentially closed, pollutants tend to build up and become concentrated in a limited volume of air. Olsson & Lyons(1) have described the buildup and transport of air pollution over Chicago in the lake breeze. Cooling tower plumes from large towers could form highly persistent haze and cloud layers in such a circulation.

III Potential for Cooling Tower Fog

Preliminary results of our analysis indicate that cooling towers would create significant problems at Zion due to fog, icing, and increased cloud cover.

The rate of release of evaporated water to the atmosphere from all cooling towers required to satisfy cooling requirements at the Zion plant would average 18,000 gal/min. It should be pointed out that, because of the large size of the plant, this quantity of water is considerably greater than that released at most locations where cooling towers are now utilized. The anticipated adverse effects are a direct result of the large quantity of water and prevailing meteorological conditions at the site.

Computations have been made of the concentrations of water which would be added to the atmosphere downwind of the plant. For mechanical draft towers, concentrations at ground level exceeding one gram of water per cubic meter of air will frequently occur. These computed concentrations, when compared to natural water content and saturation limits, indicate the following:

1) Fog will occur at the ground one mile downwind of the towers on many occasions. These will primarily occur during the early morning hours from fall through spring.

2) Ten miles downwind of the plant, fog will occur on some occasions with weak mixing and high humidity. It is estimated that such occurrences will be experienced approximately 400 hours per year.

In addition to this direct fogging situation for which the evaluation was made, there would be an additional fog source when mechanical tower fans have to be reversed in winter to prevent freezing.

Since fog will occur a significant number of times, even at a distance of 10 miles, and winds from the Lake occur at least 30% of the time, fog plumes will at times interfere with highway traffic and aircraft operations at Waukegan. Also, since much of the fogging will occur at temperatures below freezing, icing on vehicles, power lines, and structures is to be expected.

Natural draft cooling towers would provide less potential for ground-level fog, because of the greater initial height attained by the plumes. If towers are restricted to 250 ft. in height, significant fogging is to be expected, though not as frequently as with mechanical draft towers.

The greatest hazard to be expected from very tall natural draft towers will be due to cloud layers and persistent plumes above ground level. These towers do on occasion produce quite extensive plumes in the free atmosphere above the ground. Such plumes have not usually been considered troublesome. However, they can provide a hazard to aircraft operations near airports. A single plume on rare occasions is probably not significant, but the eventual existence of a large number of cooling towers in one geographical area such as Southern Lake Michigan could lead to troublesome amounts of tower-produced cloud. A particular problem is anticipated at Zion because of the presence of local lake breeze circulations along the lake shore during spring and summer. This circulation will at times tend to collect and concentrate released water in a layer overlying the lake shore and extending inland, producing cloud and haze conditions which could interfere with Waukegan Airport traffic.

IV Discussion

A recent report by the Federal Water Quality Administration(2) refers to several surveys of existing power plants where cooling towers are employed. According to the report, these surveys have found few environmental problems with cooling towers. However, the surveys primarily covered fairly isolated, natural draft cooling towers. Experience with other types of cooling, very large units, and stations in heavily populated areas, is very limited. It is worth noting that even the natural draft units surveyed have experienced occasional problems ranging from icing to fog and light snowfall.

An independent survey, conducted by Power Engineering Magazine(3) does indicate a substantial number of environmental problems. Of the 47 utilities surveyed who used cooling towers or ponds, 39 reported the existence of problems. There were 17 reports of ground fog effects and 20 reports of icing problems. These numbers seem particularly significant because the larger plants surveyed were all in the southwest or arid plains states. Problems would be expected to be more widespread and serious in other parts of the country.

Potential for fog formation by cooling towers is discussed in the FWQA report referred to previously. There, it is concluded that "such effects do not seem to be a problem for the Lake Michigan area." Our results differ with this conclusion for the specific Zion site. We have utilized observed meteorological conditions for the area, and proposed specifications for cooling tower equipment that would be required at Zion. Under these conditions, our rather extensive calculations result in significantly higher fog probabilities than are obtained for the general case by FWQA.

Though our quantitative analysis has been limited to cooling towers, some general statements can be made about other cooling methods. Spray cooling canals would be expected to have a fog potential greater than cooling towers, since the water is released to the atmosphere at ground level. Ponds, because of their much larger area, are less of a fog hazard. However, even ponds are known to produce heavy fog in areas close to the pond. We strongly agree with the FWQA's recommendation that sites for all types of evaporative cooling equipment be chosen on the basis of detailed meteorological surveys, and should avoid close proximity to highways, airports, and other fog-sensitive operations.

Dry cooling towers represent an environmental situation about which least is known. Certainly the large quantities of heat released to the atmosphere will result in an increase in convection, turbulence, and cumulus clouds. Whether these will produce any significant meteorological consequences is beyond the current state-of-the-art to predict. There is strong evidence that man-made changes of precipitation and weather are found downwind of some large cities. These are believed to be, at least in part, a consequence of heat from the city. Thus, there is some reason to believe that the very large quantities of heat released by dry cooling towers for a plant the size of Zion could lead to detectable changes in the average weather conditions downwind.

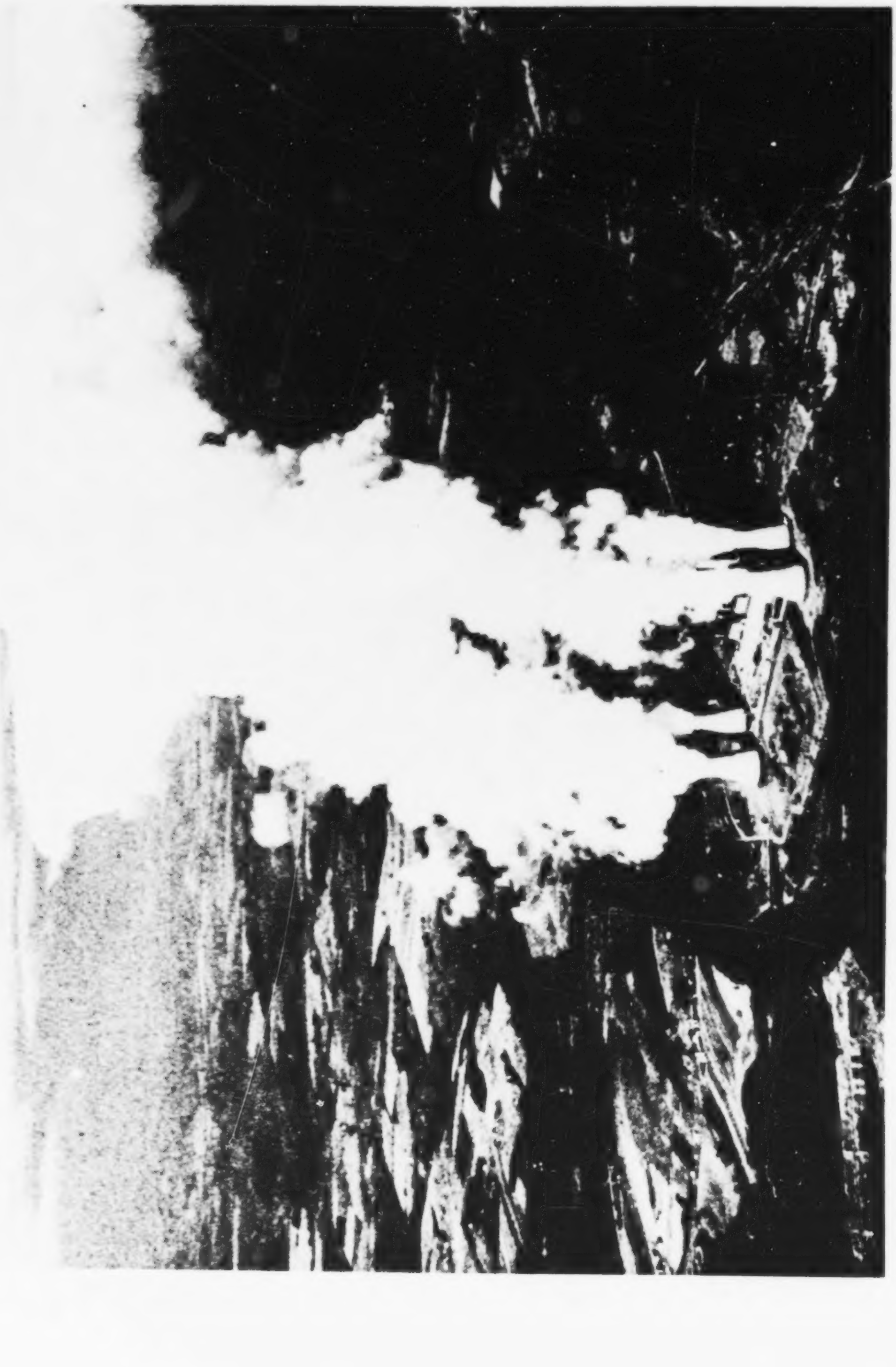
In summary, it appears that environmental problems, some well-defined and others more vague, are associated with all proposed cooling techniques. We strongly support the FWQA's recommendation that careful site environmental studies precede the decision to use any particular cooling method at a given plant. In the case of the Zion station, our studies indicate that fog potential, in particular, is relatively high. Because the site is located in a populated area close to highways and airports, environmental effects of cooling towers may be expected to produce significant problems.

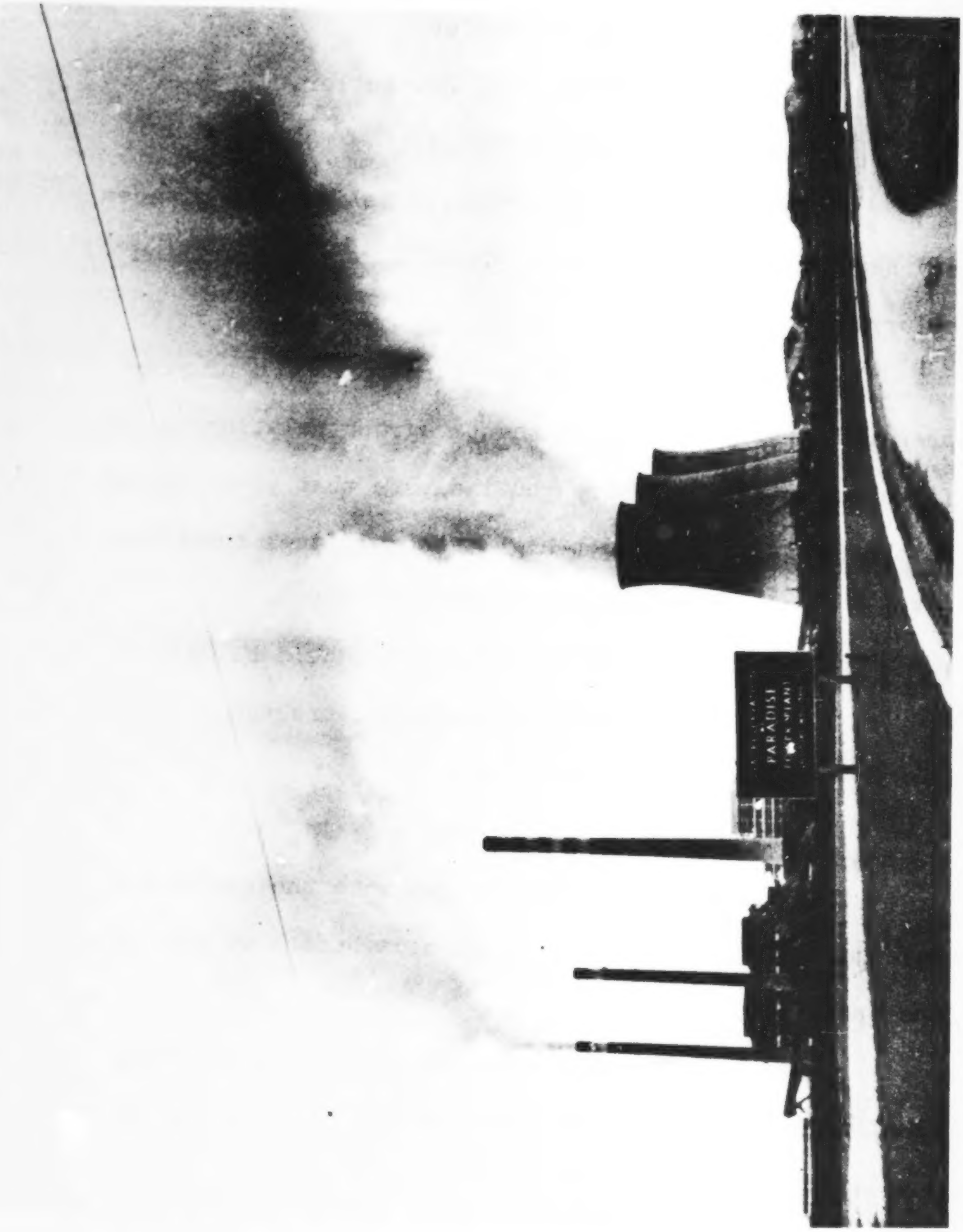
References

1) Olsson, L.E., and W.A. Lyons: Air Pollution Dispersion in a Lake Breeze Regime. Paper presented at the 62nd Annual Meeting of the Air Pollution Control Association, June 22-26, 1969, New York.

2) Feasibility of Alternative Means of Cooling for Thermal Power Plants near Lake Michigan. National Thermal Pollution Research Program, U.S. Dept. of Interior, FWQA, August, 1970.

3) Thermal Effects: A Report on Utility Action, Power Engineering, April, 1970.




PARADISE
PLANT

MR. STEIN: Thank you, Mr. Butler.

Any comments or questions?

MR. BANE: Mr. Chairman, I believe the witness may have misread one figure. Could I get it clarified before examination?

Mr. Butler, would you turn to page 6 of your prepared statement down in the paragraph relating to your fifth consideration where you indicate that your request to construct the 400-foot-high meteorological tower was reduced to -- and you said orally 445 feet --

MR. BUTLER: I am sorry; it should be 245.

MR. STEIN: That will stand corrected.

Your meaning was clear.

MR. BUTLER: I am sorry.

MR. STEIN: Before we get into the questions, I have just a few of these general ones before we get into the specifics.

As I understand what you said about the Zion Plant improvements, it is that you can't really put in a cooling device now.

MR. BUTLER: No, I didn't say that they were improvements. I was really pointing out the inapplicability of them as is pointed out in the FWQA report.

MR. STEIN: You see here -- this is where I am trying to understand what you people are saying. You say if we continue to operate this and let's suppose for the sake of argument -- I am not saying you are not correct -- that there won't be any bad ecological effects, but your previous witnesses have said if there proves to be damages you will be glad to put in devices. But if the site is so located and you have made such commitments in concrete that you can't possibly do this, as things come up, then what is the point in saying you will? Let's suppose you have made a misjudgment. Let's suppose damages occur. What kind of cooling can you put in, since you have done such a good job in indicating it can't be done?

MR. BUTLER: Well, Mr. Chairman, no place did I intend to insinuate -- and I don't believe I said -- that it is not possible. It is very hard for an engineer to say that anything is not possible, and I didn't intend to insinuate that it was not possible.

MR. STEIN: All right.

Then, I certainly agree that we are close together.

Now, there is one other thing that I run into here all the time on which I really think I would like some clarification. On your first page you said, "We are convinced that in proposing to use Lake Michigan water we have selected the method of cooling which is the most desirable among the methods which we might reasonably employ at Zion."

Then on page 2, in dealing with that, you say, "... an approach which is very similar..." to a once-through cooling system.

Now, the point is, that cooling you are talking about is really condenser cooling, that is not water cooling, is it?

You haven't put anything in Zion which is designed to cool the water, and when you are talking in terms of a method of cooling, and the once-through cooling design, these all refer to cooling which you are going to use as far as your steam and your condenser operation but it doesn't refer to cooling your water before discharge, is that correct?

MR. BUTLER: It is correct, that I was referring to the cooling of the steam, and I believe that is also true of the FWQA report.

MR. STEIN: All right.

I want that to be clear, when we talk about a once-through cooling system that doesn't mean a system to cool the water; that means to cool the steam when the water gets out of it.

Any more questions or comments?

Mr. Currie.

MR. CURRIE: I have one question.

You mentioned the land shortage in regard to the possibilities of cooling ponds at the Zion Plant. Perhaps Mr. Bane is in a better position than you, Mr. Butler, to answer that question. Is it not true that Commonwealth Edison has the power of condemnation?

MR. BANE: Yes, we do have the power of condemnation. We have complications at that particular site, Mr. Chairman. There is a State park, as you know, not far to the north, and indeed we made a contribution to that park by exchanging one of our parcels for another parcel so that it could be added onto the park there. It would take braver men than we, I think, to attempt to interfere with that park.

Whether or not we could go -- I think that immediately as we go to the west -- Mr. Butler could probably answer this better than I -- but I think that as we go to the west we get into a highly built up area; is that correct, Mr. Butler?

MR. BUTLER: Yes, we do, and the land price is very high as we go to the west also. That is, in fact, the city of Zion.

MR. BANE: But there is another paper as to which

I would very much like to hear the views of the Department of Interior --

MR. STEIN: Again, sir, you may want to talk about this, because I think the philosophic approach has been one possibly which isn't going to settle this operation. You talk about material in the FWQA or the official Wildlife report, and then you say "... these observations are highly significant." Of course, you say "...in terms of our Zion site...because the site would not permit compliance with them."

Then you go on to say that you have more than 200,000 cubic yards of concrete in place. You have the dimensions of the condensing equipment already set, etc. It seems this raises the question of how far any company, by setting a plant in motion or selecting a site or building a plant, can limit the remedial options of the people responsible for protecting the environment, or whether -- and this is the same question because you can answer them both -- or whether it is the responsibility indeed of a Federal or State or local regulatory agency to give you an alternative on how you are to protect the environment. The point is if you have selected the site, selected the process and built the plant, it seems to me that the general rule of law on this, if there is a requirement that the environment is to be protected, the company doing that is responsible for coming up with the method.

MR. BANE: Well, I think that our policy statement, that was one of the first papers delivered by Commonwealth Edison Company, very clearly said if there turned out to be a need to modify or change the cooling method because of environmental damage, it would be in the future determined that we certainly stood ready to do so.

MR. STEIN: But all those have reasons against them. Do you have any methods to correct this in case you have to use it that we haven't heard of?

MR. BANE: Well, Mr. Chairman, it is very difficult to speculate on how you would modify a cooling system before you know what the problem with the cooling system is. I think there are many modifications that can be made depending upon what the problem is. We don't see any problem at the present time.

MR. STEIN: Any other questions or comments?

By the way, Mr. Butler, I don't think we are far apart. I really don't. And are there any comments or questions from the people on the floor?

DR. TICHENOR: My name is Bruce Tichenor from the Corvallis Lab of the FWQA.

One of the anonymous authors of the feasibility study paper --

MR. BUTLER: Pardon me. I can't quite hear you. I have a little hearing problem.

DR. TICHENOR: Maybe I can stand over here. It will be a little easier.

I just have some general questions and comments related to your presentation.

I notice initially that many of these comments are essentially the same as the presentation that was delivered earlier by Mr. Patterson of Sargent and Lundy.

First of all, on the first page, you make a statement that basically the authors of the report have gone to the manufacturers of cooling towers and spray pond equipment to find out whether their equipment would be suitable for powerplant use in the Great Lakes area.

I am wondering if you really have made a careful reading of the report, because I think in the report itself we point out that the procedures used in estimating and defining the costs were somewhat more sophisticated than this -- in fact, quite a bit more sophisticated -- and I think Section 4 of the report and Section 5 of the report indicated that, and I wonder if you have any comment on what sort of procedures you think we really used to come up with these cost estimates?

MR. BUTLER: Well, yes, I would be glad to comment on that.

You do mention in the report that some of your data comes from the Marley Company and some from the Ceramic Cooling Tower Company and we, of course, have had contact with those same firms.

Now, when you start to compare cost estimates from two different organizations working independently of each other, of course, it is very hard to compare the costs because neither one knows exactly where the other started and where the other ended, and neither one knows specifically the criteria under which the design was specified and, therefore, the price is affected by that design specification.

Now, I might just point out, as an example, that experienced powerplant engineers are accustomed to optimizing the capital cost of a plant with the operating and maintenance cost of a plant; where the suppliers of the equipment generally, if you go to them for an estimate price, they tend to give you the lowest estimating price unless you in a very detailed manner specify what you want.

As an example of that, just let me quote an example. As a matter of minimizing investment and operation, one company may say I will put an operator on the site and when it becomes necessary to shut the cooling towers off and drain them, I will have one or two or three operators there that can go around and twist all of the necessary valves and shut it down and drain it and protect it from freezing, and so forth.

It may, though, be more economical in the overall picture to put in more operating valves in certain locations which raise the capital cost but reduce the operating and maintenance cost in sufficient amount to justify the higher capital cost. That is why it is very difficult to compare two cost estimates of doing this, and I stated very frankly that I thought that your costs were low in comparison to our experience of estimating similar installations.

DR. TICHENOR: Yes. I appreciate your comments, and I think that in some cases you are probably directing most of these comments to capital cost.

I was more concerned with -- as you can tell by our report -- the effect of cooling systems on the production cost of electricity, and I have another statement to make on that a little later.

I think you list a total of ten points which are considerations not evaluated in the FWQA report.

MR. BUTLER: As they apply to Zion.

DR. TICHENOR: This is true. I think you appreciate the fact that that report was not meant to include backfitting as was pointed out so well by Mr. Williams of the AEP.

MR. BUTLER: I certainly do. I didn't mean to be redundant of Mr. Williams. I didn't know what he was going to say. I think we came to similar conclusions on that, and you made it quite clear in your own report. I was not picking flaws with your report in that respect but my point was that there are qualifications to your conclusion and people tend to forget the qualifications.

DR. TICHENOR: This is absolutely true. Our report did not consider backfitting. I do have some questions on these ten points even though some of them may not be particularly applicable to our report.

First of all, you make the statement that the costs of the plant wet or dry cooling towers at the present stage of construction at the Zion station are in the order of five to six times the cost estimates in the report. Again, I don't think this is a fair comparison because our cost estimates were not based upon backfitting.

MR. BUTLER: Yours were not backfitting and mine is.

DR. TICHELOR: My question is: Are these five to six times the cost -- capital costs, busbar costs, consumer costs -- what are we talking here?

MR. BUTLER: This is capital cost, with the loss of capacity that may be involved valued not at the hundred dollars a kilowatt that was used in your report but at $207 a kilowatt which is our estimated cost of the capacity at our Zion station, and in addition the poorer efficiency or the use of more fuel that would be required. The equivalent investment of the loss due to the additional fuel consumed is included in that.

DR. TICHENOR: Right.

MR. STEIN: Do you mind if I go on with something not on here but just in the general report? As I understand it, here is what happened. You have indicated that they qualified the report not to include backfitting and you said they said that was very clear, but you want to emphasize it so it wouldn't be misunderstood.

MR. BUTLER: I wanted it emphasized so that you gentlemen who are deliberating this problem would not overlook it in your deliberations. That is correct.

MR. STEIN: And then you switched four, five or six times relating to Zion, which is a backfitting report that they reported. Now, what we are doing is writing out the discharge and then using that as a main point of difference.

All right. Would you go on?

DR. TICHENOR: I would just like to ask what estimate do you think this five or six times the capital cost would have on the busbar cost?

MR. BUTLER: I have not computed that. I would be glad to do it or have it done and report, if you would like. I have not made that computation.

DR. TICHENOR: This is for backfitting. Again, lower down here there is a statement about: Even for a new plant -- now, this is reflected in our report -- the price estimates that have been made are higher and lower than the ones that you people have.

I think that this question was raised yesterday with respect to Mr. Patterson. I won't go into that. I have been talking to Mr. Patterson, by the way, and we are exchanging information. I have made available our information to him and I understand that he is going to come up with some numbers, so I won't go into that any further.

Again, I would like to emphasize again -- which has been emphasized by the consultant -- that dry towers are brought in again. I couldn't agree with them more that dry towers are not a practical alternative to backfitting a plant with a tube condenser. I can't see anyplace in our report where we even came close to inferring that that was a possibility.

I have a couple of questions related to Dr. McVehil's study. You make the statement that his preliminary findings are attached as Exhibit A, which I have read, and these preliminary findings indicate that cooling towers at Zion would create significant problems. And if these are preliminary findings, how can we come up with a conclusive statement?

MR. BUTLER: Well, the preliminary findings of Dr. McVehil are based upon the 245-foot high tower. Now, we hired this firm sometime ago to study this problem, and they have not completed their study. You will notice that in a place or two in his report he did come up with some numbers of frequency with respect to certain things, but they have not completed the report to the extent that they can say on a certain expected frequency this will happen or that will happen with respect to some of them . We are asking them to carry right on with the report and to complete their study on it.

Now, certainly Dr. McVehil can be made available for cross examination. I am not a meteorologist and I certainly can't talk -- I can't convey to you all of the reasons that he may have for his conclusions. But I think the significant point here is that the low -- relatively low wet cooling towers perform differently than the high cooling towers like Mr. Williams showed this morning. I think also that this -- what the meteorologists call the induced air flow due to being on the shore of a very large body of water seems to be from discussions with Dr. McVehil -- seems to be quite an important consideration.

MR. MAYO: May I make an observation, Mr. Chairman? I have the feeling that perhaps a liberty may have been taken with Dr. McVehil's comments. If we go to page 4, the very last sentence uses the terminology: "Environmental effects of cooling towers may be expected to produce significant problems."

Did you interpret this conclusion as being that cooling towers at Zion would create significant problems?

MR. STEIN: Well, he didn't say "will," I noticed that. They didn't say they "will" cause significant problems. Okay, go on.

DR. TICHENOR: Your Point No. 6 is that the report recognizes the possibility that removing water from Lake Michigan not to be returned may constitute an undesirable diversion.

I wonder if you considered whether or not the increased evaporation due to a once-through cooling system constitutes undesirable diversion.

MR. BUTLER: I think that is a legal question and I am, of course, no authority on interpretation of the merits of the decision. However, I only throw it out as a consideration. I didn't try to give the answer to it as you will notice.

DR. TICHENOR: Right. I think that in our report we indicated that certainly these wet devices will have higher evaporation rates than the once-through system and the data are given. But I am like you, I am not going to try to draw any conclusions on that.

On Point 9, you mentioned a specific cost omission, which is admitted in the report, land preparation and construction work associated with cooling ponds. This is true. Then you say this is such a significant cost factor that this part of the study is of limited value.

I am not too sure I agree with that, in that even if our construction costs were significantly low, the fact that we are looking at not only the effect on the cost of electricity of the capital cost but also the effect of operating the cooling system, such that we include things as fuel differential cost, would make me believe that in the end the results that come out are meaningful.

For example, if you make an error in construction cost, all other things being equal, of a million dollars, and using a fixed charge rate of about 14 percent, this makes a difference in the busbar cost of about .02 mills per kilowatt hour. So, in this case, if our cooling pond costs -- capital costs were low or even significantly low, $1 or $2 million, I think in the end when we talk about our busbar cost increase, I think you would see at least our conclusions are that it would not make a very great difference in the production cost.

MR. BUTLER: Well, I disagree with you on that completely. We have some experience in building cooling ponds, as you may know. We have our Kincaid Lake with a Minemouth station. We are building a cooling pond near Pekin, Illinois, for a new unit, and we are undertaking to build about a 4,500-acre lake at another site which Mr. Currie is very familiar with. We find that the land cost is a rather insignificant part of the cost because we are talking about moving in the order of 20 million yards of dirt to consummate this cooling pond.

Of course, the topography of the land is the controlling factor whether the land or the construction cost of the cooling pond is significant. In our cases, we find that the land is a rather insignificant part of the total cost of putting a cooling pond into service.

DR. TICHENOR: Yes. This was not my point. I will agree that leaving out the cost of construction and land preparation definitely makes our capital costs of our cooling ponds low. My point was that unless, as you suggest, the land costs are an insignificant portion, which for $1,000 an acre that would be quite an expensive cooling pond -- are an insignificant portion of the capital cost, I would agree with you, but if we missed the cost of the cooling pond by $1 or $2 million --

MR. BUTLER: Let's say $20 million.

DR. TICHENOR: -- $20 million, then I would agree.

I think we are talking here about a portion of the cost of the total cooling pond land preparation cost, and I think, in this respect, if we added $20 million to the cost of our cooling pond for, again, our 1,000 megawatt base plant, I would agree with you. But if it was $1 or $2 million, then I would think that we --

MR. BUTLER: I would agree with you, if you can build one after owning the land for $1 or $2 million, that is not significant. In the topography that I have been unfortunate enough to have to deal with, I don't think you build any 4,000 or 5,000-acre cooling ponds for -- I mean after you own the land -- for $1 million or $2 million. I just don't think there is any such topography very available. I haven't found any.

DR. TICHENOR: Okay. Cooling ponds in our report I think ranged from about 1,400 to 1,900 acres, but I don't think we are really disagreeing. I don't have any further comments.

MR. STEIN: Thank you.

Are there any other comments or questions?

Thank you very much, Mr. Butler.

MR. BANE: Commonwealth Edison's final witness is a recall of Dr. Pipes who will discuss some proposed thermal pollution standards.

STATEMENT OF WESLEY O. PIPES,
PROFESSOR OF CIVIL ENGINEERING,
NORTHWESTERN UNIVERSITY, EVANSTON,
ILLINOIS

MR. PIPES: Mr. Chairman, members of the conference, ladies and gentlemen.

During the last two-and-one-half years I have had the opportunity to study, read, and think about the effects of temperature on Lake Michigan water quality and aquatic ecology. As a result I have reached certain judgments about temperature criteria for protection of the lake and would like to present these judgments for your consideration. My studies of temperature effects in Lake Michigan were the result of a request from Commonwealth Edison Company that I advise them on this subject. However, these judgments are my own personal opinion and do not represent a position of any agency.

Purpose of Water Quality Criteria

I believe that the intent of water quality criteria is to protect the value of water as a natural resource. In this context it would be as much a squandering of natural resources to adopt criteria which are so strict as to prevent the beneficial use of Lake Michigan as it would be to adopt criteria which are so lax as to allow degradation of water quality and destruction of aquatic life. I believe that it is possible to develop water quality criteria which will allow all users of Lake Michigan, the municipalities and industries, as well as the fishermen, boaters, and swimmers, to make optimum beneficial use of this resource without interfering with each other.

In approaching the problem of temperature criteria for Lake Michigan I have formulated a series of questions. The answers to these questions provide a scientific basis for deciding which of the proposed criteria best meet the objective of maintaining the value of the water as a natural resource. I will first present these questions and the answers which I have obtained and then comment on some specific items of the proposed criteria.

Temperature Change

On the subject of temperature criteria for Lake Michigan the first question to be answered is:

Should any temperature change from normal water temperatures be permitted?

W. O. Pipes

I believe that the available data and scientific evidence clearly demonstrate that moderate temperature changes over small areas of Lake Michigan have not caused any degradation of water quality or any damage to aquatic communities. I have studied one area of temperature increase in Lake Michigan intensively myself and have found evidence that no detrimental effects are occurring. I have examined reports by scientists who studied other areas of temperature increase in Lake Michigan and found that no detrimental effects are described. I have studied articles by other scientists who hypothesized that certain detrimental effects might occur as a result of temperature increases in certain areas of Lake Michigan but have found these hypotheses to be based on speculative calculations and translation of laboratory data to natural environments.

There is no scientific evidence from studies of Lake Michigan to support the need of a criterion of a 1-degree temperature rise at the point of discharge to protect water quality and aquatic ecology of Lake Michigan. Indeed, there is substantial ecological evidence to support the concept that modest temperature increases over small areas of Lake Michigan have no detrimental effects.

If I could elaborate for a moment, Mr. Chairman,

W. O. Pipes

I would like to point out -- I said detrimental effects -- there are ecological changes, and we are attempting to measure the magnitude of these ecological changes. We have fairly good limits, I think, on the magnitude of the ecological changes. We don't know precisely what the measurements will be.

I might also point out that the introduction of coho salmon into Lake Michigan was a very large ecological change -- a much larger ecological change than we are talking about here. Whether or not this is a detrimental effect on Lake Michigan is a matter which is presently being debated among fisheries' biologists.

The types of temperature effects which may be occurring in Lake Michigan due to present powerplant discharges are subtle changes in the biological populations which comprise the aquatic communities. If they do occur in the lake, they should be measurable at certain times of the year at temperature increases in the range of 5 degrees to 10 degrees F. above the normal water temperature. Obviously, if we can find no changes at 5 degrees F. above normal water temperature, we can feel quite comfortable in concluding that no change will occur below that level. In the rest of this statement, I am referring to the areas in the discharge plumes which are 5 degrees F. or greater above normal water temperatures.

Mixing Zones

I believe that the available scientific evidence and the calculations and conclusions based on this evidence demonstrate that the heat from discharges of condenser water from steam electric generating units having a capacity between 1,000 and 1,100 MW is dissipated in a relatively small area around the point of discharge and that these discharges can be designed so that the temperature will be reduced to within 5 degrees F. of normal water temperature in less than 1 mile from the point of discharge. These discharge plumes would have no measurable temperature effect upon the water at a distance of 3 miles from the point of discharge. The judgments which I am making in this statement depend on the conclusion that the types of thermal discharges proposed for Lake Michigan will have no measurable effect on the overall temperature of the lake. Given this position the second question to be answered is:

How large should mixing zones be?

I am considering discharges which would have no measurable effect on lake temperature at a distance of 3 miles from the point of discharge. Because of the normal configuration of thermal plumes these discharges would create mixing zones having areas less than 1 square mile if a temperature change of 5 degrees F. from ambient water temperature is taken as the edge of the mixing zone. In my judgment a limited number of mixing zcnes of this size with moderate temperature increases (5 degrees F. to 20 degrees F.) in the mixing zones can be allowed without running a significant risk of degradation of water quality or damage to aquatic communities.

This judgment is based on the following facts:

1) In water depths less than 10 feet in Lake Michigan the benthic organisms are very sparse. In water depths greater than 10 feet the warmest part a thermal discharge plume floats and there is little temperature effect on the benthic community.

2) In discharge plumes with an area of less than 1 square mile the time of exposure of planktonic organisms to temperatures 5 degrees F. or gerater above ambient is less than one-quarter of a day. The planktonic organisms in the lake have generation times of 1 day and longer. Thus, the plankton are exposed to increased temperatures for periods much less than their generation

times.

3) Fish are normally expected to seek out their preferred temperatures and will be present in the mixing zone when the temperatures there are near these preferred temperatures.

How Many Mixing Zones

The judgments on mixing zones are made with the knowledge that there are, and probably always will be, some uncertainties about the effects of temperature change on the aquatic communities. If a conservative viewpoint is taken, these uncertainties become risks. Given the concept that some risks are associated with allowing mixing zones this large, the third question to be answered is:

How many of these mixing zones should be accepted?

The surface area of Lake Michigan is 22,400 square miles. If we assume that it is acceptable to take small risks with 1 percent of the lake surface, then 224 square miles of surface area could be utilized for mixing zones. This area would allow a total of 224 nuclear units of 1,000 to 1,100 MWe capacity if individual mixing zones are limited to 1 square mile. This is far more plants than are likely to be built on the lake.

Mr. Chairman, I want to emphasize the point that I am not proposing to allow construction of anywhere near that number of powerplants on Lake Michigan.

This judgment is made on the assumption that the mixing zones which are permitted will be studied. There should be continuing study of the aquatic ecology of Lake Michigan and the effect of temperature changes upon the aquatic communities in these mixing zones. There should also be a reevaluation of the temperature standards periodically as more information about temperature effects becomes available. I believe that several years of study will produce scientific evidence to support the judgment that the temperature criteria we are considering at the present time are conservative.

Here, Mr. Chairman, what I am saying, on the basis of the scientific evidence we go in the direction which the data points. You do not take a look at the data you have and assume that the next batch of data that you have will contradict the first batch of data you have, and I believe that this is the scientific view on this. I think after sitting through 5 days of hearing -- or the last 6 days -- now I have realized that this conference needed not only scientific input but also input from other fields of endeavor. I am just trying to express the scientific use of the data in this context.

It has been speculated by some that the most important period for temperature effects on Lake Michigan organisms will be the months of March, April, and May. There is evidence to indicate that during these months the thermal barrier in Lake Michigan inhibits the mixing of shore waters with the open areas of the lake. If these ideas are correct—and I think it has been brought out here very well that this particular point is a matter of considerable debate in the scientific community at the present time—but if these ideas are correct, then we are dealing with an area to protect which is much smaller than the 22,400 square miles of lake surface.

The Department of Interior "white paper" on thermal effects (September 1970) concludes that the so-called inshore area must be separately considered because it is the most biologically productive area. That inshore area, defined as the area from the shore to a depth of 100 feet, contains some 5,040 square miles Again, as you have heard, there is considerable question in the scientific community of the adequacy of this definition. That is, defining inshore zone as the area in which the depth is less than 100 feet. So there is still some debate, as a matter of fact some considerable debate about that point.

The largest portion of that area lies within Green Bay, and the inshore area, excluding Green Bay for the moment, contains about 1,500 square miles.

Now, if we take an extremely conservative position for the moment and assume that the inshore area ought to be separately considered, mixing zones of the size I am discussing do not now present a problem. There are nine large units now under construction around the lake. While I have not studied all of them, I am reasonably sure that their mixing zones will occupy, even if added together, less than 1 percent of the inshore area, even excluding Green Bay.

As a result, I believe we have clearly not yet reached the point at which an unreasonably large number of mixing zones 1 square mile in size are planned for the lake. That point presumably will be reached in time, and I believe it reasonable for regulatory bodies to consider fixing an interim limit on the total number of large plant sites until such time as studies of the present discharge plumes can be completed.

Temperature Rise

Having answered the questions of how large and how many mixing zones, the next question which arises is:

What should be the temperature rise allowed at the edge of the mixing zone?

In order to arrive at an answer to this question, it must be stated again that we are dealing with practical questions of locating a particular isotherm on the lake surface. In my experience the uncertainty of locating a particular isotherm is about 1 percent of the distance from the shore. In other words, the uncertainty in locating a temperature difference of 1 degree F. at a distance of 1 mile from shore is about ±500 feet. At smaller distances from the shore and for larger temperature differences the uncertainties of measurement decrease rapidly. I estimate that it should be possible to locate a temperature difference of 3 degrees F. at a distance of 1 mile from shore within a range of ±250 feet and a temperature difference of 5 degrees F. within a range of ±100 feet.

I believe that the temperature rise selected for the edge of the mixing zone should be realistic in terms of a reasonable degree of precision in measurement. The measurements have to be made in terms of both measuring changes in aquatic communities and in terms of locating a particular point in the lake. A 5 degree F. temperature change would be readily measurable and also marks point below which biological changes are most unlikely. My previous discussion of the size and number of mixing zones was based on a definition of a 5 degree F. temperature change at the edge of the mixing zone. If a different temperature change were used for defining mixing zones the areas would have to be revised.

MR. STEIN: Dr. Pipes, may I interrupt there, because I think this might help.

I know you probably wrote this before you got here this week.

DR. PIPES: Right.

MR. STEIN: In view of what we heard about the difference of opinion and the way people look at thermal plumes and tongues of heat going in and out would give us a difference of plus or minus 200 feet or plus or minus 100 feet. Are you really suggesting that this would be appropriate thinking? I want to do this before you come to your conclusions as consenting to this. Do you think this is appropriate that we can administer this, companies are going to be happy with the results, you are going to be happy with the results and the regulatory agencies are going to be happy with the results if we start checking these plus or minus when they vary?

DR. PIPES: Well --

MR. STEIN: Go on, because I didn't want you to get locked into your conclusions first. I know you put this before -- I am trying to look at a way out of this, but you go on. I just meant to flag that. I don't want to pursue that point.

DR. PIPES: Well, I am going to comment on this in just a minute as an interjection here. When I wrote this I was thinking about problems of measurement.

MR. STEIN: That is right.

DR. PIPES: There is first the problem of locating a particular isotherm on the surface of the lake. And the second point is the question of deciding whether this is a temperature change from the natural water temperature of so much -- so many degrees.

Now, I think what I am trying to say here is that in terms of measurement and the precision of the instruments that we have available at the present time, if you are talking about temperatures changes of the order of magnitude of 5 degrees, then we can be fairly certain to say that this is the plume, this is not the plume. When you are looking at the temperature changes in the order of magnitude of 1 degree then there is a great degree of uncertainty whether you are in the plume or measuring ambient temperature.

MR. STEIN: I think it is one area maybe we can come to an agreement on with all concerned. I am not arguing about this scientifically and I am not arguing about using these as theoretical considerations to set up a mixing zone. But what I am saying, sir, is that I think this would be better for the industry as well as the regulatory agency if we can agree on an area of regulation. That is why I suggested the pipe. Even though you go to higher temperature, you relate this theoretically to what would happen in the mixing zone. Because if we are going to do what I heard this week, we will be here interminably on every alleged violation or not-alleged violation.

DR. PIPES: I am not familiar with all of the problems of enforcement. I do think that it is possible to measure temperatures of -- well, temperature measurements fairly accurately with a thermometer to a hundredths of a degree and so forth, but locate a point in the lake at which there is a measurable temperature difference from ambient. So, I am concerned with measurement here really more than enforcement.

MR. STEIN: Okay. All right.

DR. PIPES: Comments on proposed standards, and I interject here at this point that these comments were written in reference to a series of three proposals -- the ones which are officially under consideration by the State of Illinois, as I understand. I have seen proposals from some of the other States, and I felt it more appropriate to comment on the proposals which are before the Illinois Pollution Control Board rather than try to cover the whole thing.

Following the discussion of what I believe to be the pertinent questions which must be answered, to establish temperature criteria for Lake Michigan and how I would answer them, it is appropriate to comment on some of the previous proposed temperature criteria.

The description of the mixing zone as having a length of radius in feet given by $100\sqrt{Q}$ where Q is the discharge rate in cubic feet per second is quite conservative in terms of our present experience with previously existing discharge plumes. I really have no knowledge of where this particular formulation came from. I understand it is a formulation which Mr. Mayo presented in the State of Michigan last April. I would point out that this formulation does limit the mixing zone to smaller areas than I was talking about earlier, mainly because of the type of configuration you have to use for the discharge in order to meet this standard.

And, as I say, I believe it is quite conservative in terms of our present experience with previously existing discharge plumes and biological effects in these plumes. It is, however, a standard which can be met with a reasonable engineering design, except perhaps in the case of a small discharge. I have really not looked at any application of this when X is a very small number and realize there is some mathematical problems in calculating if you get a very low Q.

In other words, I am saying that this is a -- I think in view of the biological information we have, this is a very conservative estimate of the size of the mixing zone, and it would limit the actual mixing zones in the lake that are smaller sizes than the ones I have been talking about earlier.

An allowable temperature rise of 3 degrees F. at the edge of the mixing zone is very conservative and probably too restrictive. An allowable temperature rise of 5 degrees F. at the edge of the mixing zone is more realistic in terms of allowing measurement of any of the postulated temperature effects on aquatic communities if they do occur. The organisms in Lake Michigan are subjected to normal temperature variations which are a part of the natural environment to which they have adapted. The formulation of temperature standards in terms of allowable temperature rise above ambient is more realistic for preserving the natural temperature variations than setting maximum temperatures on a month-by-month basis.

Again, I am not familiar with all of the previous input in the area of writing proposed criteria. I am assuming that the month-by-month maxima in the various sets of tables which are going around is basically an attempt to define what is ambient so we can get away from the problems of measurement.

The monthly temperature maxima which were listed in Mr. Klassen's letter of August 12 to Mr. Currie as a part of proposal No. 2, as far as I have been able to ascertain, have no relationship to the temperature requirements of aquatic organisms. Indeed, for several months of the year the normal water temperature in the inshore area exceeds the proposed maximum a significant fraction of the time.

I believe that the temperature standards for Lake Michigan should not contain any reference to the 96-hour median tolerance limit for aquatic life. One of the gentlemen from Michigan pointed out to me that between August and September they had dropped this out of their State proposal. However, I understand that it is still a part of the proposal in Illinois and therefore, we will comment on it.

W. O. Pipes

This criterion is inconsistent with other concepts of the proposed standards because:

1) The reference is to a maximum temperature which will persist for only a few seconds and in an area having a radius of, at Zion, for example, of 100 feet. Regarding such an area as critical would, as a matter of logic, require you to prohibit the building of discharge works into the lake because they occupy as much space.

2) Planktonic organisms are subjected to the maximum temperatures in the mixing zone for periods of time much less than 96 hours. You remember what Dr. Pritchard shows in a matter of seconds, perhaps minutes.

3) The scouring action of the discharge will prevent any benthos from occupying the area of maximum temperature and so none will be exposed to these temperatures.

4) Fish have the option of leaving areas in which the temperature exceeds their tolerance limit and evidence indicates that they do.

5) This, I suppose, is related to the problem of enforcement. There are hundreds and perhaps thousands of organisms in Lake Michigan for which the 96-hour median tolerance limit temperature is not known and years of laboratory work will be required to find out

what this specification means.

Use of a 96-hour TLm, in effect reduces the proposal to one governing the temperature at the point of discharge, which is not consistent with the mixing zone concept on which the remainder of the proposal is based. The concept of a 96-hour TLm is useful for discussing water masses which have a uniform temperature. It is not directly applicable as a regulation governing discharges which constantly decline in temperature.

Summary

To summarize, I believe that the appropriate regulation at this time is one which limits the number of plants located around the lake until the presently planned studies are completed and evaluated, and limits each plant to a reasonable mixing zone and a 5 degree F. temperature rise at the edge of that mixing zone.

MR. STEIN: Any comments or questions?

I don't know, I can hardly contain myself.

MR. CURRIE: Dr. Pipes, you are concerned that we should limit the size and number of mixing zones, and I take it also the spacing of mixing zones around the lake, so that we don't have a number of them right together, is that right?

DR. PIPES: I might point out that -- all along there have been a number of other considerations in, let's say, the spacing and location of these mixing zones that have been brought out. Dr. Robertson suggested yesterday the mixing zones should be located so that there would be no warming of the thermocline, and the hypolimnion, it has been suggested, in these mixing zones be located so that it not affect fish spawning grounds and such things.

Excuse me. I am not answering your question directly. In answer to your direct question, I think the spacing of the mixing zones should be limited so that the possibility of interactions of the plumes is at a very low temperature differential.

MR. CURRIE: Yes. Do you also have any thought that we ought to limit the temperature inside a mixing zone itself, or should we be content if someone wanted to discharge water which would create mixing zones of a square mile in which the temperature was 40 or 50 degrees above ambient?

DR. PIPES: Well, I don't know of anybody that was proposing to discharge water at this type of temperature increase. There certainly are temperatures -- temperature increases which would definitely do damage to aquatic communities in Lake Michigan. I would like to ask if you really want me to say exactly at what point of temperature rise you get damage to aquatic ecology. I don't have the particular figure for this.

MR. CURRIE: But I take it that your acceptance of the mixing zone concept is based on an expectation that temperatures within the zones themselves will not be as much as to cause gross pollutional effects. Therefore, we should be concerned with the temperature inside the zone itself so that it doesn't get completely out of hand.

DR. PIPES: One of my basic assumptions is that we are avoiding detrimental pollutional effects, or I will say ecological changes, that certainly are acceptable in limited areas.

MR. CURRIE: So you are saying that there may be some harm within the mixing zone itself.

I was about to ask you if you didn't think that there was going to be any harm within the mixing zone, why should we limit the size of the number of these zones? And I think you have given me the answer. You are saying not that there won't be any harm within the mixing zones but that the area involved is so small that we can afford to give up that part of the lake.

DR. PIPES: No, I think in the statement -- if I can find the particular place -- well, I can't point out the page right now. What I am saying is there are certain changes which very likely do occur in the mixing zones. We do not yet have the data to say specifically what these changes are. We do have the data to say they are of rather small magnitude and I hope we can find the magnitude precisely within another year.

What I am saying is that if you take a conservative position, then any change in the environment becomes a risk. What I am saying is that it is this concept of risk associated with the mixing zone -- and let's minimize the risk -- associated with the mixing zones by limiting the number of mixing zones until we have further information.

MR. CURRIE: Now, you are interested in eliminating the size of the zone. I remember Dr. McWhinnie testifying last week before our Board as to the difficulty of measuring.

I think this is the kind of point that Chairman Stein was just raising, measuring the ambient temperature and where the mixing zone really ends.

I wonder what your opinion would be as to the relative advisability of doing it the way you suggest by the limiting of an area for the mixing zone or rather by determining on the basis of standard models, or something like that, the approximate area of plume that would be expected from a given volume and temperature of discharge, and then making it an effluent limitation rather than a mixing zone definition limiting, in fact, directly the temperature and volume of the discharge, so as to accomplish roughly your same goal. Wouldn't that be administratively more feasible?

DR. PIPES: Well, as I understand, let's say, the approach that he used here, is that this conference is talking about water quality criteria. What would we like to achieve in terms of protecting aquatic community and enhancing the water quality in Lake Michigan? And this is the intent of the statement is to discuss this area.

Last week, Dr. McWhinnie, I think, probably was wiser than I was, when she refused to give any specific recommendations on the stand. I realize in doing this I am running certain risks, but certainly I am not an expert in enforcement.

I would say, however, that the informational studies made and the information and studies I have seen that other people have made indicate that the area of influence, the area of measurable temperature influence from a discharge at a given volume, a given temperature rise, can vary considerably depending upon the engineering and the design of the discharge point, and my own experience with standards is that very often we engineer into law a particular type of discharge which prevents further engineering development. In other words, if you take today's present models and say, "All right. This is what we can do at the present time and, therefore, we will inscribe as a law you do this." Then, this inhibits further engineering ingenuity, further improvements in the state of the art, and I think there are -- well -- some areas in our society -- for instance, building codes, I think, have sort of inhibited a good many possible improvements in building methods and materials, and so my own philosophy in this is that as much as possible the criteria should be performance criteria and the engineers should be given the opportunity to use their ingenuity to do as good a job as they can. Hopefully the job will get better as time goes on, as we learn more about some of the problems.

MR. STEIN: Well, let me start with your last point first.

I think possibly you don't know the antecedent of some of the people on the Board but a lot of us came from the old Public Health Service operation. As a matter of fact, I hate to tell you how many years Perry Miller and I were co-working on septic tanks. So you can see how far we have gone. And I grew up on these building codes. I worked on the hygiene codes, and if you want to look at something, look at the building codes sometime and see the restrictive area. I think that given that and given our experience, we have more or less avoided that in the field of water. We recognize the limitations and we don't fold those in.

We have a couple of examples in where the drinking water coliform standards were so highly regarded in New York that the New York State Legislature enacted them into law, and a couple of the New England States have had the Legislature classify their efforts. Other than that, I don't think we have much of that any more.

DR. PIPES: Mr. Stein, if I can interject, I hope -- this is a very personal opinion -- I hope there will be a continuing reevaluation of these standards as we go along, and we won't get into some of the traps of legislating these things into permanent standards.

MR. STEIN: We have said that over and over again. Among other jobs I have, I am in charge of the standards setting program for the Federal Government. We have said that over and over again about reevaluating it. This is why some of the States may be a little irritated on the reevaluating technique, but we recognize this is not going in law.

We recognize always that when you are constructing any of these plans, it is kind of a moving target we are putting before you. It is good one year, but it may not be good 5 years from now.

Let me get back to the main point. I guess if you are around this operation long enough, things begin repeating themselves. But when we first went out, in dealing with the pulp and paper industry in the Pacific Northwest, I can still see in my mind's eye, Mr. Vinton Bacon, who I think was in Chicago for a while and before that he was working for the pulp and paper industry in the Pacific Northwest, between the time he was in Chicago and the head of the California agency.

Mr. Vinton Bacon, in presenting an argument for the pulp and paper industry with a big map of Puget Sound, said, "Look at this big sound." And then he would draw a little circle outside the outfall of every paper plant and say, "This is the little area of risk you are taking with the bay -- with Puget Sound." And this was the argument, then. And you might want to read the history of that as to what happened subsequently in that case.

But I don't think what you are saying is very much different, and we have run into that before.

DR. PIPES: I think the big difference in this case, Mr. Stein, is that the evidence we have does not show pollutional effects of these thermal discharges in Lake Michigan.

MR. STEIN: I think if you read Mr. Bacon's statement at the time he said practically the same thing. "The evidence we have" -- as a matter of fact, he showed his charts of salmon and stuff -- no pollutional effect. That is true. I am not arguing the validity.

But here is what I want to get down to, sir. I want to get down to your conclusion, the summary. "I believe that the appropriate regulation at this time is one which limits the number of plants located around the lake until the presently planned studies are completed and evaluated, and limits each plant to a reasonable mixing zone and a 5 degree Fahrenheit temperature rise at the edge of that mixing zone."

Now, if we have this 5-degree mixing zone, would there be any plant that you know of under construction now on the planning boards or proposed that would have to put in any cooling devices or could just get by with this once-through shot?

DR. PIPES: There are only two plants with which I am really quite familiar: This is Waukegan Station which has been operating for 40 years and Zion Station which is under construction.

I have no personal knowledge of the mixing zones or the discharge plumes from the other plants. Now, this --

MR. STEIN: I think the basic issue is whether the regulatory agencies are going to require the plants to put in cooling devices. After hearing some of the other testimony and in talking about this 5-degree temperature at the end of the mixing zone an allowable operation, I would take it, unless I hear to the contrary, that we ought not require any special cooling devices.

Therefore, as Mr. Currie said, you don't have to have too many of these, but we limit the number of the plants.

Now, here is what you are proposing. It is precisely that area over which the water pollution control people and the ecological people have the least amount of jurisdiction. We don't set the plant sites initially. There are other agencies that do it. Traditionally we have not gotten into land use but let anyone use something for a land use if they can meet ecological considerations.

In other words, what you are suggesting to this board is that the limitation put on the plants to save the lake be in the area of the restriction on land use. But when we have a land use, we have a relatively broad operation in the mixing zone in order that no cooling devices will be required.

DR. PIPES: Well, my consideration on the mixing zone -- what I said was -- again, going in the direction in which the scientific evidence indicates -- and I also said rather clearly that after the two days of hearing in Illinois last Friday and Saturday and the three days of hearing now, I realize that there are inputs other than scientific, but I am just expressing the scientific input.

MR. STEIN: Are there any other comments or questions?

If not --

MR. PURDY: I have one question, Professor Pipes.

Your recommendation with respect to the mixing zones -- with your recommendations with respect to the mixing zones, do you believe that it would be possible to have infrared flights made to determine whether or not the mixing zones are not being exceeded in size?

DR. PIPES: Well, infrared flyovers are certainly one way of measuring temperature. I have not studied the question of how fine a measurement -- in other words, the accuracy of locating a point by infrared flyover technique at small temperature rises. I know that surface temperature measurements can be made this way.

MR. STEIN: Are there any other comments or questions? Any from the audience?

If not, thank you very much, Professor Pipes.

Mr. Bane, does that conclude the --

MR. BANE: Yes, that concludes the Commonwealth Edison presentation. We wish to thank the conferees for their patience in listening to us. I think Mr. Petersen will now --

DR. PIPES: Excuse me. There are some additional copies of the study plan that we were talking about yesterday.

MR. STEIN: By the way, I wish to express my appreciation to you, Mr. Bane, for interrupting your presentation to accommodate others, and we appreciate the presentation and the spirit in which it was made and thank you very much for cooperating with us.

MR. BANE: Thank you.

Mr. Petersen, I think, will handle the program from now on.

MR. STEIN: Yes.

MR. PETERSEN: In accordance with the previous arrangement, Mr. Chairman, Witnesses Aschoff and Patterson of Consumers Power Company -- of Sargent and Lundy for Consumers Power Company are now made available for such questions as may be asked.

MR. STEIN: Are there any other questions?

If not, does that conclude the power company presentation?

MR. PETERSEN: No, there will be two more presentations, I think, of a total of about 45 to 50 minutes total at most. Wisconsin Public Service Company and Wisconsin Electric Power Company have not appeared and as far as I know those will be the last of them.

MR. STEIN: Well, I think in view of the time, let us -- would you come up here? -- and let us talk to the States and let's take an in-place recess.

(Short recess.)

MR. STEIN: Let's reconvene, please.

Mr. Petersen, will you continue?

MR. PETERSEN: The next presentation will be by Mr. Evan W. James, Vice President, Power Generation and Engineering, for Wisconsin Public Service Corporation.

STATEMENT OF EVAN W. JAMES, VICE PRESIDENT, POWER GENERATION AND ENGINEERING, WISCONSIN PUBLIC SERVICE CORPORATION, GREEN BAY, WISCONSIN

MR. JAMES: Mr. Chairman, conferees, ladies and gentlemen in attendance at this workshop. I am Evan W. James, Vice President, Power Generation and Engineering, with the Wisconsin Public Service Corporation. I appreciate having the opportunity to state briefly our position and a few thoughts. I will appreciate having these remarks made part of the record.

MR. STEIN: Without objection, these remarks will be entered into the record as if read.

(The remarks above referred to follow in their entirety.)

STATEMENT OF WISCONSIN PUBLIC SERVICE CORPORATION PREPARED FOR WORKSHOP SESSION OF THE FEDERAL-STATE ENFORCEMENT CONFERENCE ON POLLUTION OF LAKE MICHIGAN SCHEDULED FOR THE WEEK OF SEPTEMBER 28, 1970

Wisconsin Public Service Corporation, whose address is P.O. Box 700, Green Bay, Wisconsin 54305, is a public utility organized under the laws of the State of Wisconsin. It is engaged principally in the production, transmission and distribution of electricity and the purchase and distribution of natural gas. It also operates a small urban bus system in the Green Bay area. In the 12 months ended May 31, 1970, it received 63.7% of its operating revenues from the sale of electricity, 35.9% from the sale of gas and 0.4% from its bus operation.

The Corporation's total investment in utility plant at the end of 1969 was $311,627,418.

The Corporation serves approximately 210,000 electric customers and 116,000 gas customers in northeastern Wisconsin and an adjacent part of Upper Michigan. The largest cities served are Green Bay, Sheboygan, Oshkosh and Wausau. It furnishes electricity in all of these cities except Sheboygan and gas in all except Wausau.

The Corporation has a total capability of electric power available from generating units wholly or jointly owned of 760,000 kilowatts. Of relevance in this matter are the Pulliam fossil-fired steam plant at Green Bay located at the confluence of the Fox River and Green Bay wholly owned by the Corporation and the Edgewater fossil-fired steam plant unit No. 4 at Sheboygan on the shores of Lake Michigan owned jointly with Wisconsin Power & Light Company, this Corporation having a 31.8% interest. The maximum load on the Corporation's electric system for the 12 months ended May 31, 1970, on a 1-hour integrated basis was 622,000 kilowatts on February 16, 1970. A new peak of 651,000 kilowatts was reached in early August 1970.

The Corporation is a party to a power pool agreement with Wisconsin Power & Light Company and Madison Gas & Electric Company under which these three utilities commenced sharing reserve generating capacity on January 1, 1970. Pursuant to this agreement the Corporation is building for the pool a nuclear generating plant near Kewaunee on the west shore of Lake Michigan. This unit will have a net generating capability of 527,000 kilowatts which will be shared by the three pool members, this Corporation having a 41.2% interest.

Pulliam Plant

The Pulliam plant originally designated as the Bayside plant was placed in service in 1926, the first installation consisting of two 10,000 kilowatt turbogenerators. Coal was originally delivered by railroad, but in 1928 a dock was constructed and since that time fuel has been delivered by lake freighter.

A third generating unit was placed in operation in 1943. This added 30,000 kilowatts to the plant's capability. In 1947 a fourth unit, also 30,000 kilowatts, was placed in operation. Construction of a fifth unit of 50,000 kilowatt capacity was completed in 1949 and a sixth of 62,500 kilowatt capacity in 1951. In 1958 a seventh unit of 75,000 kilowatt capacity, and in 1964 an eighth unit of 125,000 kilowatt capacity were completed.

The capacity of Pulliam's eight units is listed as 392,500 kilowatts. Construction of all the units was made with the approval of the Public Service Commission of Wisconsin and pertinent federal and state regulatory bodies.

The Pulliam plant is located in an industrial area in the northwest section of the City of Green Bay. A residential area commences about 3/4 of a mile away to the south. The site is low land with the area immediately to the west of the plant until recent years being swamp land. This land is being filled by normal processes and by extensive transfer of river bottom silt.

With the plant being located at the mouth of the Fox River as it enters Green Bay, the Bay being a part of Lake Michigan, it has intakes on both the River and Bay fronts. The circulating water conditions vary considerably with wind and season. Water inlet temperatures vary from 33°F to 83°F. The temperatures, however, exceed 80°F only a small fraction of the time. For the period July 1, 1969 to June 30, 1970 the inlet water temperatures were as follows: They exceeded 70°F 15.62% of the time; 75°F 7.40% of the time. During this period there was no intake at a temperature in excess of 80°F.

Normal circulating water use is 480,000,000 gallons a day with a maximum temperature gradient + 16°F. During the five summer months the high monthly average ΔT is 11.4°F; during the seven colder months it is 13.7°F; the yearly average is 12.8°F. The discharge from the plant is directed to the River side where mixing occurs in the River stream.

A number of the comments which follow and which are directly related to the Kewaunee Nuclear Energy Plant have application to Pulliam also.

Kewaunee Nuclear Energy Plant

Under the terms of the power pool agreement previously referred to, this Corporation became the builder of the nuclear plant now in the course of construction on the Lake Michigan shoreline approximately 8 miles south of the City of Kewaunee. An application to construct this 527,000 kilowatt (net) nuclear plant (the reactor is a Westinghouse pressurized water reactor) was made to the Public Service Commission of Wisconsin in March 1967 (Docket CA-4759 and 2 WP 2570), and to the Atomic Energy Commission in August of 1967 (Docket 50-305). Approval was received from the Public Service Commission in October 1967 and from the Atomic Energy Commission in August 1968. Ownership of the plant is being shared 41.2% by Wisconsin Public Service Corporation, 41.0% by Wisconsin Power & Light Company, and 17.8% by Madison Gas & Electric Company. The plant is planned for commencement of operation in October 1972. Responsibility for construction and operation of the plant rests with this Corporation. It has thus developed contacts with other interested governmental units such as the Corps of Engineers and the Wisconsin Department of Natural Resources. It has procured all permits and approvals necessary to this stage of construction.

Selection of the Kewaunee site was primarily determined because of its proximity to the electrical system of the Wisconsin pool, the availability of Lake Michigan cooling water and the favorable topography of the area.

The plant is being constructed in a sparsely populated region devoted to agriculture and dairy farming. The City of Green Bay is 30 miles northwest, and Milwaukee is about 90 miles southwest.

Temperatures taken at the intake to the City of Green Bay water system which is located in Lake Michigan north of the City of Kewaunee indicate that the temperature of the Lake exceeds 50°F only 32% of the time, 55°F 19%, and 59°F only 11%. The average temperature range based on ten years' experience 1957-1967 is from an average low of 34°F to an average high of 62°F. The maximum experienced during this period was 68°F and this occurred on only one occasion.

Although the latest technology available is being incorporated into the Kewaunee plant, its thermal efficiency, as is true of large nuclear stations generally, is only about 33-34% [redacted]. As a consequence, about 66 67% [redacted] of the heat generated in the plant has to be disposed of in one form or another. A major portion of this heat is removed through the electric power plant's circulating water system which passes the water through a steam surface condenser where the heat is absorbed. The circulating water system of the Kewaunee plant draws Lake Michigan water from an area approximately 1,750 feet from the shoreline at a depth of 15 feet. The water flows through a submerged 10-foot diameter steel pipe at a rate of 400,000 gallons per minute during summertime operation, and 270,000 gallons per minute during the winter. The water flows from the steel pipe under the lake bed into an open forebay into the screenhouse structure. Equipment for cleaning the water and the circulating water pumps are also located in the screenhouse. The water is pumped into the turbine building where it is passed through the steam surface condenser and then returned to the Lake. The system relies on the natural effect of a syphon for return of the water to the Lake.

Based upon design data during the five summer months, the maximum ΔT will be 19.3°F. The average ΔT for the summer months will be considerably less.

An extensive environmental study of the area surrounding the Kewaunee plant has been carried on dating back to almost four years prior to start-up in order to obtain background information. The company will continue a program of monitoring the surroundings for the life of the plant to be certain plant operation has no adverse effects.

Without going into extensive detail we can give a brief explanation of what the company's environmental program is with respect to discharges at Kewaunee. The company has four areas of environmental effort under way which can be summarized as follows:

1. A meteorological study by company engineers and by NUS Corporation of Rockville, Maryland, has been and is in progress in which the winds in the area are continually monitored so their direction and variances can be studied in detail.

2. A background information study of the lake area adjacent to the site is under way. This study is conducted by personnel of the University of Wisconsin - Milwaukee under the provisions of a grant from the three parties to the Wisconsin power pool. This study includes obtaining pertinent data and information on the water, lake bottom conditions, and plant and animal life in the water and underwater areas.

3. A preoperational study of the site and shore area is being conducted by Industrial Bio-Test Laboratories of Northbrook, Illinois. The purpose of this program is to establish background measurements for land and shore areas near the site. This study includes obtaining data and information on airborne particulates, well water, surface waters, lake bottom organisms, bottom sediments, slime, vegetation and soil. This work is being continued after September 1, 1970 on an even broader basis.

4. Kewaunee is also participating in a general study of Lake Michigan as it may be affected by nuclear plants through work being performed by the Research Department of the University of Michigan. This study which covers the lower two-thirds of Lake Michigan is being financed by the six utilities (and their associates) who are or will be building nuclear plants on the shores of Lake Michigan. Sampling includes water and where possible bottom samples. A portion of this effort has been completed and will be reported on in the near future.

As respects Kewaunee both the intake and discharge structures have been designed through the aid of hydraulic models to achieve efficient flow of water so as to have the least possible effect on both the shore and the lake. Of interest in this connection is the fact that environmental studies thus far made indicate that apparently the lake bed and waters in the Kewaunee area do not contain significant quantities of plant, fish or animal life.

As already pointed out, environmental surveillance programs will be continued after operation of Kewaunee begins so that there will be continuing data available. This will enable the utility and the regulatory bodies to evaluate the impact of the plant's operation and thus, if necessary be able to prescribe changes in plant or procedures.

To conclude, there are two points to be emphasized:

1. Lake Michigan cooling water is a natural resource available for use to benefit the public in the generation of reasonably-priced electric energy - there being, as we believe, based on credible evidence, no adverse effects of such use. Both Pulliam and Kewaunee plants have been designed to use this resource, and any substantial limitation on its use will interfere drastically with their operation.
2. This corporation is following the regulations of the State of Wisconsin respecting thermal emissions, which regulations have been approved by the United States Department of the Interior, and we are firmly convinced that

no modifications of such regulations are required on the basis of information and data presently available.

MR. JAMES: Wisconsin Public Service Corporation, whose address is P. O. Box 700, Green Bay, Wisconsin 54305, is a public utility organized under the laws of the State of Wisconsin. It is engaged principally in the production, transmission and distribution of electricity and the purchase and distribution of natural gas. It also operates a small urban bus system in the Green Bay area. In the 12 months ended May 31, 1970, it received 63.7 percent of its operating revenues from the sale of electricity, 35.9 percent from the sale of gas and 0.4 percent from its bus operation.

The corporation's total investment in utility plant at the end of 1969 was $311,627,418.

The corporation serves approximately 210,000 electric customers and 116,000 gas customers in northeastern Wisconsin and an adjacent part of Upper Michigan. The largest cities served are Green Bay, Sheboygan, Oshkosh and Wausau. It furnishes electricity in all of these cities except Sheboygan and gas in all except Wausau.

The corporation has a total capability of electric power available from generating units wholly or jointly owned of 760,000 kilowatts. Of relevance in this matter are the Pulliam fossil-fired steam plant at Green Bay located at the confluence of the Fox River and Green Bay wholly owned by the corporation and the Edgewater fossil-fired steam plant unit No. 4 at Sheboygan on the shores of Lake Michigan owned jointly with Wisconsin Power and Light Company, this corporation having a 31.8 percent interest. The maximum load on the corporation's electric system for the 12 months ended May 31, 1970, on a 1-hour integrated basis was 622,000 kilowatts on February 16, 1970. A new peak of 651,000 kilowatts was reached in early August 1970.

The corporation is a party to a power pool agreement with Wisconsin Power and Light Company and Madison Gas and Electric Company under which these three utilities commenced sharing reserve generating capacity on January 1, 1970. Pursuant to this agreement the corporation is building for the pool a nuclear generating plant near Kewaunee on the west shore of Lake Michigan. This unit will have a net generating capability of 527,000 kilowatts which will be shared by the three pool members, this corporation having a 41.2 percent interest.

Pulliam Plant

The Pulliam Plant originally designated as the

Bayside plant was placed in service in 1926, the first installation consisting of two 10,000 kilowatt turbo-generators. Coal was originally delivered by railroad, but in 1928 a dock was constructed and since that time fuel has been delivered by lake freighter.

A third generating unit was placed in operation in 1943. This added 30,000 kilowatts to the plant's capability. In 1947, a fourth unit, also 30,000 kilowatts, was placed in operation. Construction of a fifth unit of 50,000 kilowatt capacity was completed in 1949, and a sixth of 62,500 kilowatt capacity in 1951. In 1958, a seventh unit of 75,000 kilowatt capacity, and in 1964, an eighth unit of 125,000 kilowatt capacity were completed.

The capacity of Pulliam's eight units is listed as 392,500 kilowatts. Construction of all the units was made with the approval of the Public Service Commission of Wisconsin and pertinent Federal and State regulatory bodies.

The Pulliam plant is located in an industrial area in the northwest section of the city of Green Bay. A residential area commences about 3/4 of a mile away to the south. The site is low land with the area immediately to the west of the plant until recent years being swamp land. This land is being filled by normal processes and by extensive transfer of river bottom silt.

With the plant being located at the mouth of the Fox River as it enters Green Bay, the Bay being a part of Lake Michigan, it has intakes on both the river and bay fronts. The circulating water conditions vary considerably with wind and season. Water inlet temperatures vary from 33 degrees F. to 83 degrees F. The temperatures, however, exceed 80 degrees F. only a small fraction of the time. For the period July 1, 1969, to June 30, 1970, the inlet water temperatures were as follows: They exceeded 70 degrees F. 15.62 percent of the time; 75 degrees F. 7.40 percent of the time. During this period there was no intake at a temperature in excess of 80 degrees F.

Normal circulating water use is 480 million gallons a day with a maximum temperature gradient + 16 degrees F. During the five summer months the high monthly average Delta T is 11.4 degrees F.; during the seven colder months it is 13.7 degrees F.; the yearly average is 12.8 degrees F. The discharge from the plant is directed to the river side where mixing occurs in the river stream.

A number of the comments which follow and which are directly related to the Kewaunee nuclear energy plant have application to Pulliam also.

Kewaunee Nuclear Energy Plant

Under the terms of the power pool agreement previously referred to, this corporation became the builder of the nuclear plant now in the course of construction on the Lake Michigan shoreline approximately 8 miles south of the city of Kewaunee. An application to construct this 527,000 kilowatt (net) nuclear plant (the reactor is a Westinghouse pressurized water reactor) was made to the Public Service Commission of Wisconsin in March 1967 (Docket CA-4759 and 2 WP 2570), and to the Atomic Energy Commission in August of 1967 (Docket 50-305). Approval was received from the Public Service Commission in October 1967, and from the Atomic Energy Commission in August 1968. Ownership of the plant is being shared 41.2 percent by Wisconsin Public Service Corporation, 41.0 percent by Wisconsin Power and Light Company, and 17.8 percent by Madison Gas and Electric Company. The plant is planned for commencement of operation in October 1972.

Responsibility for construction and operation of the plant rests with this corporation. It has thus developed contacts with other interested governmental units such as the Corps of Engineers and the Wisconsin Department of Natural Resources. It has procured all permits and approvals necessary to this stage of construction.

Selection of the Kewaunee site was primarily determined because of its proximity to the electrical system of the Wisconsin pool, the availability of Lake Michigan cooling water and the favorable topography of the area.

The plant is being constructed in a sparsely populated region devoted to agriculture and dairy farming. The city of Green Bay is 30 miles northwest, and Milwaukee is about 90 miles southwest.

Temperatures taken at the intake to the city of the Green Bay water system which is located in Lake Michigan north of the city of Kewaunee indicate that the temperature of the lake exceeds 50 degrees F. only 32 percent of the time, 55 degrees F. 19 percent, and 59 degrees F. only 11 percent. The average temperature range based on 10 years' experience 1957-1967 is from an average low of 34 degrees F. to an average high of 62 degrees F. The maximum experienced during this period was 68 degrees F. and this occurred on only one occasion.

Although the latest technology available is being incorporated into the Kawaunee plant, its thermal efficiency, as is true of large nuclear stations generally, is only about 33.34 percent. As a consequence, about 66-67 percent of the heat generated in the plant has to be disposed of in one form or another. A major portion of this heat is removed through the electric powerplant's circulating water system which passes the water through a steam surface condenser where the heat is absorbed. The circulating water system of the Kewaunee plant draws Lake Michigan water from an area approximately 1,750 feet from the shoreline at a depth of 15 feet. The water flows through a submerged 10-foot diameter steel pipe at a rate of 400,000 gallons per minute during summertime operation, and 270,000 gallons per minute during the winter. The water flows from the steel pipe under the lake bed into an open forebay into the screenhouse structure. Equipment for cleaning the water and the circulating water pumps are also located in the screenhouse. The water is pumped into the turbine building where it is passed through the steam surface condenser and then returned to the lake. The system relies on the natural effect of a syphon for return of the water to the lake.

Based upon design data during the five summer months, the maximum Delta T will be 19.3 degrees F. The average Delta T for the summer months will be considerably less.

An extensive environmental study of the area surrounding the Kewaunee plant has been carried on dating back to almost 4 years prior to start-up in order to obtain background information. The company will continue a program of monitoring the surroundings for the life of the plant to be certain plant operation has no adverse effects.

Without going into extensive detail we can give a brief explanation of what the company's environmental program is with respect to discharges at Kewaunee. The company has four areas of environmental effort under way which can be summarized as follows:

1) A meteorological study by company engineers and by NUS Corporation of Rockville, Maryland, has been and is in progress in which the winds in the area are continually monitored so their direction and variances can be studied in detail.

2) A background information study of the lake area adjacent to the site is under way. This study is conducted by personnel of the University of Wisconsin, Milwaukee, under the provisions of a grant from the three parties to the Wisconsin power pool. This study includes

obtaining pertinent data and information on the water, lake bottom conditions, and plant and animal life in the water and underwater areas.

3) A preoperational study of the site and shore area is being conducted by Industrial Bio-Test Laboratories of Northbrook, Illinois. The purpose of this program is to establish background measurements for land and shore areas near the site. This study includes obtaining data and information on airborne particulates, well water, surface waters, lake bottom organisms, bottom sediments, slime, vegetation and soil. This work is being continued after September 1, 1970, on an even broader basis.

4) Kewaunee is also participating in a general study of Lake Michigan as it may be affected by nuclear plants through work being performed by the research department of the University of Michigan. This study which covers the lower two-thirds of Lake Michigan is being financed by the six utilities (and their associates) who are or will be building nuclear plants on the shores of Lake Michigan. Sampling includes water and where possible bottom samples. A portion of this effort has been completed and will be reported on in the near future.

As respects Kewaunee both the intake and discharge structures have been designed through the aid of hydraulic models to achieve efficient flow of water so as to have the least possible effect on both the shore and the lake. Of interest in this connection is the fact that environmental studies thus far made indicate that apparently the lake bed and waters in the Kewaunee area do not contain significant quantities of plant, fish or animal life.

As already pointed out, environmental surveillance programs will be continued after operation of Kewaunee begins so that there will be continuing data available. This will enable the utility and the regulatory bodies to evaluate the impact of the plant's operation and thus, if necessary, be able to prescribe changes in plant or procedures.

In this connection, I should advise you that our position on future planning for Lake Michigan is directly opposed to certain suggestions made by some speakers recently about withholding further development on the lake for some more or less indeterminate time.

We are satisfied that the evidence now available calls for no such drastic moves in the face of the growing demands for electric service, and the capital demands on our economy. Surely reasonable regulatory rules can be established and monitoring of the environment conditions so that no damage from the thermal discharge can result. This I might add, is the fact as respects the northern part of the lake where our installations are and will be constructed.

Evidence of any damage or potential damage to the cold northern half of the lake is simply nonexistent. Frankly, I have no information, no data which permits me to go to the Board of Directors of the Wisconsin Public Service Corporation or to the boards of our partners in the Kewaunee project to request millions of dollars to add cooling towers and to inform them that I am in turn decreasing the capacity and the efficiency of the Pulliam or the Kewaunee plants.

To conclude, there are two points to be emphasized:

1) Lake Michigan cooling water is a natural resource available for use to benefit the public in the generation of reasonably-priced electric energy -- there being, as we believe, based on credible evidence, no adverse effects of such use. Both Pulliam and Kewaunee plants have been designed to use this resource, and any substantial limitation on its use will interfere drastically with their operation.

2) This corporation is following the regulations of the State of Wisconsin respecting thermal emissions, which regulations have been approved by the United States Department of the Interior, and we are firmly convinced that no modifications of such regulations are required on the basis of information and data presently available.

I thank you, Mr. Chairman.

MR. STEIN: Thank you, Mr. James, for a very forthright statement.

I don't think there is any doubt of what your position is and where you stand.

Would you identify yourself for purposes of the reporter?

MR. McKERSIE: My name is Jerome McKersie.

Mr. James, on page 9 you mentioned the preoperational study by Industrial Bio-Test Laboratories, and it is our knowledge that this preoperational study dealt strictly with radioactivity. Are you saying here that the study will be background information on thermal measurements and so forth now?

MR. JAMES: Yes, to the present point, Mr. McKersie, it has largely been pointed to the radiological. There are some areas of it which go into the thermal and the thermal aspects of the study are part of the broadening that I referred to. They have already broadened their study in that particular area.

MR. STEIN: Are there any other comments or questions from the panel?

Are there any from anyone in the audience?

If not, thank you very much.

MR. JAMES: Thank you, sir.

MR. PETERSEN: The next presentation will be by Mr. Sol Burnstein -- correction, Burstein, Senior Vice President, Wisconsin Electric Power Company.

STATEMENT OF SOL BURSTEIN, SENIOR VICE PRESIDENT, WISCONSIN ELECTRIC POWER COMPANY, MILWAUKEE, WISCONSIN

MR. BURSTEIN: Mr. Stein and members of the conference, ladies and gentlemen.

My name is Sol Burstein. I am Senior Vice President of Wisconsin Electric Power Company, headquartered in Milwaukee, Wisconsin. For further information as to the nature of the utilities I represent, the territory and number of customers we serve and other aspects of our operation, I refer you to my statement at the Third Session of the Lake Michigan Conference held in Milwaukee on March 31, 1970. Suffice it to say, that as the largest utility in the State of Wisconsin, most of the two million people we serve and all of our steam powerplants are irretrievably tied to the west shore of Lake Michigan.

This conference has been called basically because the industrial users of Lake Michigan waters vigorously opposed the policy statement announced by the Department of the Interior at the Executive Session of this conference held on May 7, 1970. That statement as quoted to us is as follows:

"The minimum possible waste heat shall be added to the waters of Lake Michigan. In no event will heat discharges be permitted to exceed a 1 degree F. rise over ambient at the point of discharge. This will preclude the need for mixing zones."

If this, indeed, remains the position of the Department of the Interior today, we are still opposed to its implementation as we were at the time of its announcement. Nothing has occurred since then either in the form of new data, new interpretations of existing facts or breakthroughs in alternative systems that provide a legitimate basis for reconsideration.

As we understand, these sessions are beyond the normal context of the proceedings authorized by statute. We believe they proceed from the May 7 Executive Session and the requests at that time and since then by nonstate participants for opportunity to be heard. These sessions are being called "workshops," which indicate an opportunity for information and discussion, and we are pleased to participate on this basis.

It is recognized that events of this last week have considerably changed the approach many of us had taken in preparation for this discussion. Following the May 7 policy statement, many of us concerned with Lake Michigan waters met with Assistant Secretary Klein and others in the Deparment of the Interior in attempts to develop an understanding of the basis of the Department position. We were advised that the Department would issue a so-called "white paper" and would schedule further hearings at which opportunity for discussions would take place. The hearings were postponed to this date and the intervening silence from the Department of the Interior on the issuance of the "white paper" prompted us, and I believe others, to proceed on the basis that no position paper by the Department would be available in time for this meeting. Distribution of the two reports, almost on the eve of these sessions, together with the announcement of the resignation of Assistant Secretary Klein, must be confusing to others, as it is to me.

MR. STEIN: I don't like to interrupt again, and you have a lot of points here, but if you want to take the opportunity to link the resignation of the Assistant Secretary with these reports and you think there is some kind of connection or something to it, I guess that is your privilege.

MR. BURSTEIN: In this respect, sir, I can only report what I have read.

MR. STEIN: And you have read there is a connection?

MR. BURSTEIN: No, sir.

MR. STEIN: Then what kind of a non sequitur is this? I don't mind what is said objectively, but if you are dealing on the basis of personalities, what does that sentence mean? We have kept this discussion -- and I think we have had fine cooperation from the industry -- from personalities up to now. I can't understand what the purpose is.

MR. BURSTEIN: I don't mean to engage in personalities, sir. It was just that the reports were issued and the newspaper announcement of Mr. Klein's resignation, who was a proponent of the policy as far as we know, occurred coincidentally.

I attach no other significance to that coincidence.

MR. STEIN: Well, you have said they were confusing.

MR. BURSTEIN: Yes, sir.

MR. STEIN: All right, go on.

MR. BURSTEIN: I have said we were opposed to the implementation of the May 7 policy statement or guideline or whatever you may wish to call it. I think it is important to ask why. In these days of environment politics and general utility criticism it would be expedient and certainly considerably easier for us to either agree with the policy statement, or at least take no position at all. Assuming all of us in industry could quickly pass on the increased construction and operating costs to our customers, as some have charged, what would we and our stockholders have to lose? In fact, some have said we might be able to make more profits on a larger rate base. So why do we appear in opposition?

It is simply that adoption of this policy will place undue economic burdens on the public and on other natural resources and other aspects of our environment without any measurable compensatory benefit. We would be pouring hundreds of millions of dollars and millions of tons of fuel, mineral and other resources into systems that on the basis of present knowledge and, in our considered analyses and judgments, would gain us practically no yield.

We have, on past occasions, participated in the Lake Michigan Conferences and have indicated what we believe to be responsible and realistic positions. In our March 31 appearance we made specific observations and recommendations concerning the objectives of the Four-State Lake Michigan Conference, among which were the following:

1) An adequate and reliable power supply is vital to this region and to the Nation, and electric utilities must have the use of adequate sites for powerplants needed to meet these requirements.

2) Problems associated with plant locations concern Federal and State regulatory agencies having responsibility in regard to electric power supply, and also concern agencies having responsibility for environmental quality. These are not necessarily mutually conflicting concerns and, in the total public interest, they must receive appropriate consideration and, if necessary, compromise.

The Federal Water Pollution Control Act requires that standards of water quality shall take into consideration "their use and value for public water supplies, propagation of fish and wildlife, recreational purposes and agricultural, industrial and other legitimate uses." In enforcing these standards, the courts are required to give "due consideration to the practicability and to the physical and economic feasibility of complying with such standards."

Despite these clear-cut statutory provisions and despite the testimony offered in previous sessions, the Department of the Interior has chosen to pursue only the single course which it believes will protect certain species of fish in Lake Michigan. Is this the only objective, and does this discharge the obligations of the Federal Government in respect to Lake Michigan?

We have looked to the Department of the Interior for leadership in helping to evaluate the present status of Lake Michigan waters and to assist in defining criteria for the future utilization of this vital resource. The Department has to date responded with an arbitrary position that has forced users of Lake Michigan waters to be in opposition, sometimes even with each other and leaving the general public dismayed and confused in the midst of these conflicts.

We are currently building two 500,000 kilowatt units known as the Point Beach Nuclear Plant, one of which is complete and ready for operation. Its operation is being delayed because of a petition for intervention filed by interested citizens who are concerned with the environmental effects of this facility, among which are the thermal discharges from the plant. We believe that a lack of a clear-cut, realistic and constructive policy by the Department of the Interior is partially responsible for this delay since the absence of such policy forces concerned individuals to seek resolution of these matters in other licensing procedures. In recent days, the shortage of electric power in the eastern part of the United States has received national attention and is due entirely to the lack of adequate generating capacity, a major cause of which has been similar unclear and indefinite environmental criteria.

We regret not having sufficient time to give deserving review to the contents of the two reports distributed by the Federal Water Quality Administration on September 18. We believe, and recommend to this Conference, that some provision will have to be made for future opportunity to present detailed discussion and comment. Our quick inspection of these reports, however, causes us to make the following comments:

1) We are pleased to note that the 1 degree F. temperature rise limit and reference to mixing zones have disappeared from the recommendations of the Department, leaving the general criteria "for ecological reasons that no significant discharge of waste heat into Lake Michigan should be permitted." I, therefore, conclude that the only item on which we need to agree is what constitutes a significant discharge of waste heat.

2) The report specifies that currently (1968) a

value of .05 B.t.u./sq. ft. per day of waste heat is added to Lake Michigan and that this would grow to .52 B.t.u./sq. ft. per day in the year 2000, applied to the entire lake surface. This represents 1/7,000 of the natural rate of heat input today, and with the tenfold increase predicted would be only 1/700 of the natural heat addition in the year 2000. No case has or can be made for the effects of these powerplant thermal discharges on Lake Michigan as a whole. We note that the projections for present and future waste heat additions are based on a 100-percent capacity operation. We wish we could operate this way. Our system capacity factor is currently about 65 percent and, with more air conditioning and not enough electric heating, we expect it to drop in the next decade.

Thus, estimates of 431 billion B.t.u./hr. calcualted for the year 2000 are more nearly like 250 billion B.t.u., and would then result in nearly half the fractions referred to in subsequent arithmetic comparisons. Using the report figures, industrial heat inputs to Lake Michigan, as noted above, are essentially insignificant.

3) The report attempts to define an inshore zone and a beach zone for comparative temperature arithmetic purposes only. We disagree with the opinion that says

S. Burstein

heat additions, as presently proposed (which we interpret to mean once-through cooling for steam powerplants) is essentially a cumulative problem. We note that the report has observed natural temperature changes at inshore surface water at as much as ± 18 degrees F. in less than 24 hours. Our records indicate even greater natural temperature variations along shorelines over relatively few hours. Changes in the wind direction, the report states, induce those large changes in the temperature of the entire inshore zone, further demonstrating the insignificant contribution of powerplants.

I submit that shoreline turbidity and the erosion of vast quantities of land along the Wisconsin shore of Lake Michigan have several orders of magnitude greater effect on the ecology of this region than any temperature change.

4) We have not been able to substantiate the theory that the principal amount of waste heat is passed to the water mass and only a small portion is dissipated directly from the plume to the atmosphere. Our plume measurements and laboratory models, confirmed by operating results, indicated otherwise, or, indeed, if mixing is the mechanism in unrestricted waters, that such mixing is so effective that no discernible

temperature change can be determined beyond the limited mixing zone. It is not appropriate to utilize dye to simulate complete heat transfer phenomena.

The report indicates Lake Michigan surface waters reach 75 degrees F. or greater in summer, and 32 degrees F. to 35 degrees F. in winter, with substantial ice formations on the surface of the lake, particularly along shorelines in winter months. To use a layman's approach, where does all the heat contained in all the surface water of Lake Michigan go between August and January?

There is only one place this heat can go, and that is from water to air. The report admits to the fact that once a body of water comes to equilibrium temperature the equilibrium is maintained by heat exchange with the air at the interface. We know that a 1,000-acre cooling pond operating at 100 degrees F., discharges essentially all of the heat input from the powerplant to the atmosphere, as confirmed in the second document on "Alternative Means of Cooling" by evidently another author. To suggest for ecological reasons that a plume (or a floating cooling pond in Lake Michigan) of the same area at the same surface temperature would not discharge the same quantity of heat via the same mechanism is untenable.

S. Burstein

5) The theoretical model for a theoretical plume is inconsistent with readily observed data. Attached to these remarks are copies of infrared imagery taken of thermal discharges at our Oak Creek Powerplant and Port Washington Powerplant. (See Pp. 1198 and 1199)

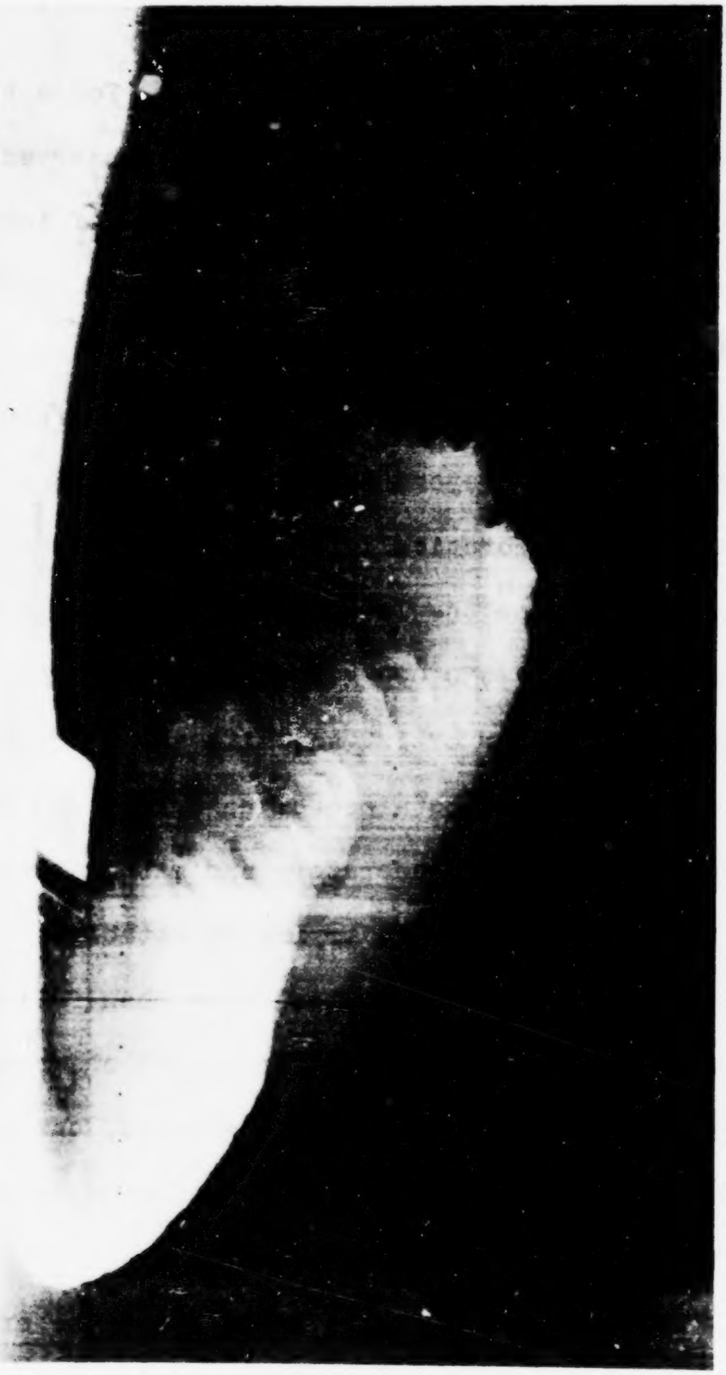
No detectable temperature differences (1 degree F.) are noted beyond about 1 mile; not 5 miles nor 20 miles, as theoretically calculated by some. The area of the plume from the largest plant on Lake Michigan, namely, the 1,670,000 k.w. thermal capacity at Oak Creek, is of the order of 1/2 sq. mi., and not the 13 or 374-sq. mi. figures obtained by calculation. It seems unfortunate that laboratory and mathematical models should be utilized in trying to establish the mechanics of plant circulating water flows when full-sized operating facilities are available for direct observation and measurement. If our data is suspect, our facilities have been offered and remain available to legitimate observers for this purpose.

6) The report talks about the expenditure of large amounts of money for control of the sea lamprey, quoting an expenditure of $6 million since 1967 by the United States and Canada, with a current lamprey control budget of $500,000. Populations of desirable fish were

THERMAL PLUME

INFRARED IMAGERY

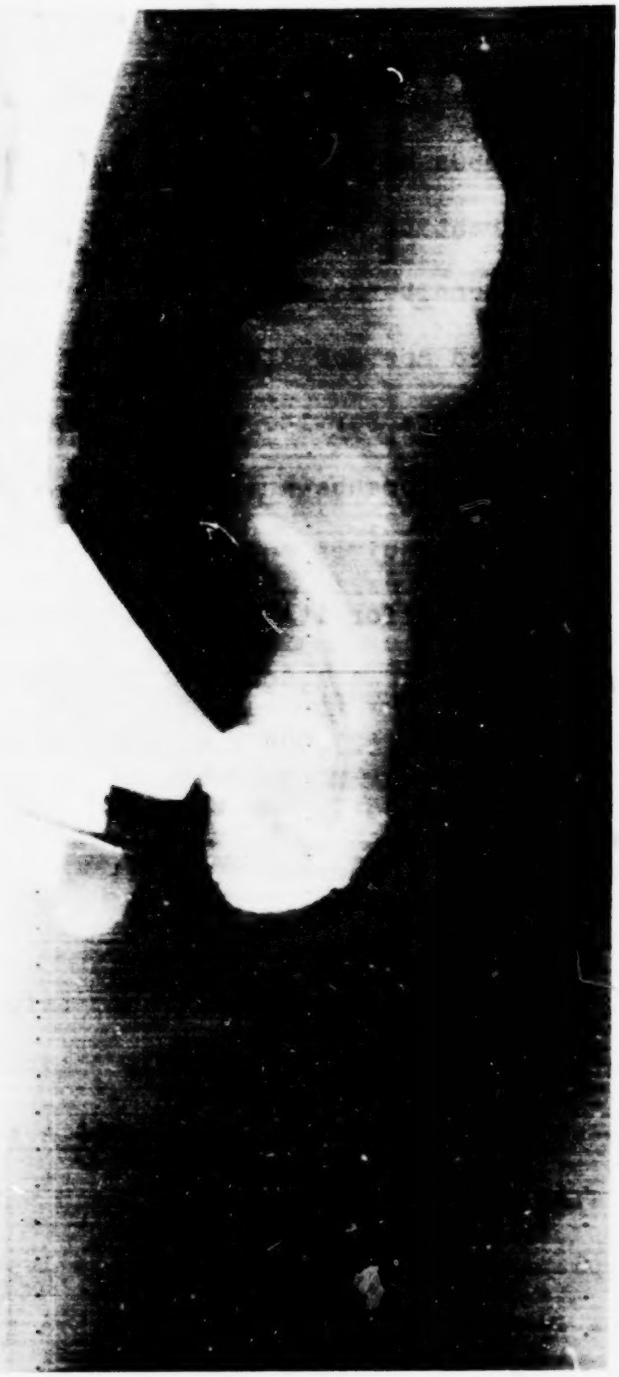
OAK CREEK POWER PLANT



THERMAL PLUME

INFRARED IMAGERY

PORT WASHINGTON
POWER PLANT



greatly reduced, the report continues, in the late 1940s and 1950s by lamprey predation. This is an immediate and real threat to the fish life of the lake, on the basis of which expenditures of the order of $500,000 annually are considered appropriate. In the same context, the Fish and Wildlife Service has the temerity to suggest that the unknown and unsubstantiated danger to fish life in the year 2000 now requires an expenditure by this company of some $60 million for its existing powerplants, plus $6 million annually. A 1,000-acre cooling pond in central Wisconsin for one 527,000 k.w. powerplant is costing our sister utilities $5.7. By the year 2000 we would be talking about hundreds of millions. These are preposterous comparisons.

7) The report makes some references to fish kills that have me confused. First, it is stated that warm water will kill fish. Then, it admits to the fact that many fish are attracted to the warmed water outfalls of powerplants where angling success is improved. The fish become acclimated to these comfortable temperatures only to be subjected to cold temperature shock and mortality due to upwellings or shutting the plant down. If this theory holds, might we not expect to have had massive natural fish kills at least six times a year, since

the entire inshore zones are subject to the rapid temperature changes recorded?

From June 1960, through December 1968, Miller of Argonne reports eleven incidents of fish kills in the United States which might have been caused by the release of warmed water from steam electric generating plants. The total number of fish kills from all causes during the same period was 2,830. The eleven episodes identified with powerplants involved the death of 81,000 fish out of a total of more than 103 million killed from other pollution incidents during the same period.

D. Merrimam of Yale found essentially no adverse effects on shad in the Connecticut River. W. L. Templeton of Battelle found thermal discharges on the Columbia had no measurable effect on the important fish resources of that body of water. Proceeding from essentially no adverse effects to predictions of disaster by extrapolation denotes a most serious fault either in the data we select to use or the techniques of prediction. In a matter which will have such long-range and significant impact on the lives of the millions of people in this area as will thermal criteria for Lake Michigan, this is not an adequate standard of performance.

8) The second report dealing with alternative

means of cooling also requires considerably more time for a more responsive comment. We note, however, that the figures for plant construction, fixed charges and operating and maintenance ratios are far below what we are, in Wisconsin, able to do today and take no account of what the industry and other branches of State and Federal establishments estimate for the future. The cost data for cooling towers and ponds are the lowest we have seen published and far more optimistic than we have been able to develop.

Even so, the report seems to deliberately avoid the mention of the total dollars involved, but they are in the hundreds of millions of dollars. There is no way of minimizing these sums which, I repeat, will be borne by the same, already over-burdened taxpayer and ratepayer.

Nowhere does the report define the additional fuel requirements for these alternative cooling arrangements. Increased fossil and nuclear fuel consumptions of from 5 percent to 20 percent are drains on irreplaceable natural resources which should be of great concern to all of us. Further, in the less efficient operation of other than once-through cooling, there is, of course, a proportionately greater heat rejection to the environment, precisely opposite in net effect to what we are trying to accomplish.

S. Burstein

Although the report mentions increased costs of land, increased evaporative losses of water, and additional chemical requirements, few references are noted as to the total effects of these intrusions on our environment, solutions to which will further escalate both confrontation and costs.

In anticipation of these sessions, we have discussed the nature of our responses with other utilities in this area. We understand that Commonwealth Edison Company is recommending that only plants operating or committed at Lake Michigan sites should be permitted once-through cooling, and that new additions to the region's generating capability should be installed only after successful demonstration of these current plants confirm that they do not adversely affect Lake Michigan and that the aggregate effect of all present plants are similar on the lake as a whole.

We disagree with Commonwealth Edison in this respect. We believe that the operation of current powerplants already demonstrates that they do not adversely affect the ecology of Lake Michigan and, as we said before, even with the present pessimism of some observers, no case is proposed that all future powerplants could by their thermal discharges affect Lake Michigan as a whole.

In Wisconsin and in Michigan we have considerably longer shorelines along Lake Michigan than Illinois and Indiana, and there are imposed upon us some different problems, as well as opportunities, than may be true for Illinois and Indiana.

Further delay in the future constructions of generating facilities in this area will aggravate an already difficult situation into one of crisis.

We consider that the heat inputs from the power industry into Lake Michigan are truly not significant in comparison with natural heat addition now or in the reasonably foreseeable future. Do not mistake our position as one of unconcern or unawareness of the problems confronting us. On the contrary, in addition to our individual enjoyment of Lake Michigan, any significant deterioration of inshore waters impairs our ability to meet our basic corporate obligation to furnish adequate and reliable electric service.

The U. S. Senate Appropriations Committee, which will undoubtedly have some say in the dollars committed to Federal programs regarding Lake Michigan, made the following comment last month.

"If we are to succeed in a sustained effort to fight pollution, the present hysteria must be replaced with knowledge and understanding. The cost of the program will be more staggering than any of the estimates now available. We cannot expect the problem to be solved immediately. Patience, understanding, and the placement of priority on the most flagrant sources of pollution should be our first consideration. The establishment of unrealistic standards which are impracticable of enforcement will adversely affect the program. Recently, The Department of the Interior recommended that water released into Lake Michigan, no matter from what source, could not be more than 1 degree over existing temperatures at the point of discharge. Certainly thermal pollution must be controlled, but the Commission*is not aware of any evidence that we need such a drastic restriction on the temperature of water discharged into the lake."

We believe that no new standards are required by the Federal authorities but that current State criteria are adequate. We believe that this can be readily confirmed by actual observations at operating steam-electric generating plants on Lake Michigan. We believe the effects of thermal discharges in localized, sensitive areas can be accommodated by proper surface discharge, the various parameters of which can be adjusted for new facilities on a case-by-case basis for each site. Anything

* See page 2159 -- corrected to "Committee."

more restrictive at this time and on the present evidence is an extraordinary burden on the people of this region that is not justified.

The position I have expressed in these remarks and those presented by other electric utilities in the last few days are offered in the best interests of the tens of millions of people served by power companies in this area. I believe the interests of these people and those of preserving the quality of Lake Michigan are compatible. I trust that the Department of the Interior or its successors in these matters will recognize that a realistic pooling of all legitimate interests in Lake Michigan can be achieved without significant penalty to either fish or people.

MR. STEIN: Thank you, Mr. Burstein.

I have one point here that I think has got us a little puzzled with the U. S. Senate Appropriations Committee quote. On the second page of the quote you are saying, "'but the Commission'" -- what commission?

MR. BURSTEIN: I believe that was a report referenced to the Atomic Energy Commission.

MR. STEIN: But this is "Commission," is it not, not Appropriations Committee? Who do you attribute this to?

MR. BURSTEIN: I believe it was by the

Appropriations Committee.

MR. STEIN: No, if they quoted it in reference to a report from that commission, is it the committee's comment?

MR. BURSTEIN: I believe it was, but I would appreciate an opportunity to clarify it for you.

MR. STEIN: All right. Are there any other comments or questions?

MR. McKERSIE: One question, Mr. Burstein. You have said that you have studies or have done studies on powerplants on Lake Michigan. Are these published studies or just within your own company?

MR. BURSTEIN: The most recently published study we have has to do with the 2 years of pre-operational environmental statistics for the Point Beach nuclear plant. That report includes a number of factors among which are the records of ambient water temperature at our intakes and in various points along the shoreline at the Point Beach site over periods of time.

For example, in these reports, we have noted the very large natural temperature variations in a few hours. As you may know also, every powerplant that I know of on Lake Michigan records circulating water temperatures, as an example, at least on an hourly basis, and have done so ever since they began operation. They are excellent sources of existing temperature data.

MR. McKERSIE: Since you mentioned that the Oak Creek powerplant is the largest plant on Lake Michigan now operating, have you done any type of monitoring on this plant, any extensive work on this plant?

MR. BURSTEIN: We have the inlet temperature data. We have discharge temperature data. We have examined the bottom of the lake and that particular area by means of visual physical inspection, utilizing divers. We have included as part of these remarks one copy of the infrared imagery, one of the photographs showing the Oak Creek powerplant at one particular time a few years ago. We do have some data.

MR. STEIN: Are there any other comments or questions?

I guess I just have to do this for the record, because there is some of this material, Mr. Burstein, that I have been principally involved with, and I think this deals with the jurisdictional question. So I think it is important to clear this up if we are going to get together with the industry and the others. You say "This conference has been called basically because industrial users of Lake Michigan waters vigorously opposed the policy statement... ."

S. Burstein

This isn't why this conference was called. The conference was called because after I made the announcement -- and I was directed to make this announcement or this recommendation -- the conferees representing the States, right here, asked for this other meeting and this policy paper. It was not from any opposition of industry. We agreed to do that right after I made that statement.

Now, we didn't even have an opportunity to hear any other comment, other than the States, when I made that statement. We made the commitment to hold this kind of meeting for the purpose of discussion. That is why it was done. The reason I have a problem here is that you talk about opposition when we are trying to resolve our problem -- that we were forced to have a meeting because of opposition. If this is the genesis, I think that stands in the way of agreement. This wasn't the case at all.

Now, again, I thought I mentioned before -- and I will say it again -- this was a recommendation. The Secretary makes policy in the Department. We do not have a policy statement. I hope you will recognize that, and I think most of the testimony was directed toward that.

Then you talk about, "If this indeed remains the position of the Interior Department today..." I told you that is why we were here, to consider this recommendation in the light of all the evidence.

Now, on the next page again you go on to say, "... new interpretations of existing facts or breakthroughs in alternative systems that provide a legitimate basis for reconsideration." By whom? I guess the industry. If you mean to imply that you have already made up your mind, I don't know.

I hope we will try to work this out.

Then you say, " As we understand, these sessions are beyond the normal context of the proceedings authorized by statute." They are certainly not. If they were we couldn't be here, and we couldn't spend public funds. They have to be authorized by statute.

Now, I don't think this kind of thing is helping us. Again, I guess I knew if I were here long enough what I was afraid was going to happen would. I knew the environmentalists would get mentioned. Read page 5. No one has said this. I haven't nor anyone I know. We recognize the difficulties of the power industry. I have seen some people make statements that the power industry wasn't planning and that is why we had these brownouts. But we all see the problems you have here today, and it is very easy to criticize someone from the outside, and

S. Burstein

I wouldn't make this against the power industry by any manner of means.

But if you say, "In recent days, the shortage of electric power in the eastern part of the United States has received national attention and is due entirely to the lack of adequate generating capacity, a major cause of which has been similar unclear and indefinite environmental criteria " -- I would submit environmental criteria have had little impact one way or the other -- either way -- on eastern power requirements.

Again, concerning your last point, may I say I have something to do with getting out these "white papers." Part of the kind of job I have is being a KP pusher in getting material out of the Department. Despite the problems we have had with this mercury crisis that we have been dealing with, I have been, along with other people, trying to push these reports out as rapidly as possible. The Fish and Wildlife Service finally got it out. This had nothing to do with any personality in the Department. The entire operation was one of mechanically doing it.

Now, I will read the quote you gave by the U. S. Senate Appropriations Committee.

"If we are to succeed in a sustained effort to fight pollution, the present hysteria must be replaced with knowledge and understanding."

I ask that we all proceed on that basis.

Do you have any comments or want to say anything then?

MR. BURSTEIN: You have invited me, and I would like to, sir.

MR. STEIN: Yes.

MR. BURSTEIN: I, of course, am not privy to the deliberations of the conference, but you may recall that the May 7th was an executive session in which we and other members of the public were not there to present testimony. We did not know we would have an opportunity to present testimony following the announcement which you read at that particular session. It was in this context that we went to see Mr. Klein, and my interview and my discussions with him are what led me to make the statements I did in this remark.

In regard to reconsideration, you are correct. It is Wisconsin Electric Power and, I believe, the other utilities who believe firmly that there are no adverse effects from the thermal discharge of our plant. If we thought there were, we would do something about them. But we cannot see the expenditure of these very, very vast sums of money without having some substantiation for them; and to date, as we have indicated, in summary, in all of the preparation for this conference, in all of the technical witnesses and the work that we have had to do in a very short time has been in response to that direction.

I would, of course, not presume to debate the matter of the statute. I have, again, felt from what I had heard in Washington that the enforcement executive session was entirely different from the public hearing types of meeting that preceded it.

I would submit, sir, that when it takes 7 years for a Consolidated Edison Company of New York, as one example, to get the license to build a hydroplant on the scenic Hudson River, most of which come from citizens concerned with environmental effects, whether they be aesthetic or whether they be river flow or others, certainly one type of evidence that environmental criteria -- not necessarily associated with Lake Michigan -- are indeed a very major cause of generating capability delays.

MR. STEIN: But you didn't say that. You said, "unclear and indefinite." The idea is if the company didn't like it and fought that for 7 years that is one thing. But I didn't know that New York had an unclear and indefinite requirement there.

MR. BURSTEIN: I believe, sir — as you know, there are many agencies dealing with the environment and evidently soon some of them will be consolidated. But in the meantime, although we have had a Federal Power Commission license for that facility, we have had changes in law, we have had changes in administration, and we have had an entire go-round with only one independent result as far as power is concerned. The plant hasn't even begun construction. And finally I must echo and share your repetition of the quotation, that the only way we are going to solve this problem is by partnership and reason and considered judgment, based on solutions to pollution by scientific people and by engineering people. They are the ones who are going to build the things; they are going to find the facts; and they are going to implement them.

MR. STEIN: Sir, that executive session -- very often they are in public -- that executive session was in public. The press watched it; the conferees watched it.

Let me assure you this -- and the record will show this -- after I made that announcement with the request from the other States -- and I assured them at that time we would have a meeting of this sort — this presumably was quite sometime before you had your meeting with Assistant Secretary Klein.

In other words, as soon as this announcement was made, and there were questions on the part of the States and the conferees, we all came to an agreement that we would have this meeting soon after the "white papers" were prepared, and we went into that discussion almost immediately and came to this conclusion very fast as I recall it.

I think we have a complete record of that in the verbatim transcript and you can read it and see.

MR. BURSTEIN: Our meeting with Secretary Klein was on May 28, sir.

MR. STEIN: After this meeting?

MR. BURSTEIN: Yes, sir.

MR. STEIN: Right. All right.

Are there any other comments? Any from the floor? Yes, Mr. Dumelle.

MR. DUMELLE: Mr. Burstein, I wonder if on that photograph in your paper you could quantify that plume as to area and temperatures?

MR. BURSTEIN: The maximum temperature from the Oak Creek powerplant on that day in question was just under 10 degrees. The photograph, we believe, is accurate, to show the demarcation at approximately the 1-degree temperature difference from our approximation of the area. It was not a precise parameter method. Some are 0.43 square miles.

MR. DUMELLE: Thank you.

MR. STEIN: Are there any other comments or questions.

If not, thank you very much, Mr. Burstein.

MR. BURSTEIN: May I take one more moment of your patient time, sir?

Mr. Purdy asked a question before which I don't know whether it was totally answered. He asked what would happen if we found some evidence of damage or potential damage by the presence of the projected thermal discharges from powerplants. Could we do anything about it?

I think the answer is, of course, yes, and I would refer to the analogy of what most of us have done in air pollution control. Where years ago a 90 percent or an 85 percent deficient dust collecting system might have been adequate, we have replaced these and in many cases replaced them two, three, and four times, with more up-to-date equipment. Nobody has been able in the past successfully to eliminate SO_2 from gases and yet now we are seeing the technical developments in areas that look like, in the next few years, we may be able to have systems and facilities to do it.

I think we can build cooling towers on any existing plant. It is going to take a heck of a lot of money. It is going to take a lot of resources of other kinds. It is going to reduce the output, but if that is the kind of a price that will have to be paid, once we know what it is, then I think it can be done.

I would like to leave that thought in response to Mr. Purdy's question.

MR. STEIN: Let me give you another suggestion. I don't say this immediately, but in the future we can think about this. I hope you weren't referring in your thinking to cooling towers. This is just my thinking. I get this from going around all over the country and answering my telephone and mail. As I pointed out, we are going to have this problem not only of heat but we have to deal with the hydrology of the intake water, the fate of the fishes, the phytoplankton, the zooplankton that go through and the hydrology of the receiving water of where you put the material out.

Now, the heat may not necessarily be the key factor on the last three. There may well be other key factors.

I am not sure when you say to put cooling towers on any system whether the requirement might not be for a pressure to come to an essentially closed system or loop-type system.

As a matter of fact, the reason I bring that up and think it is pertinent -- and I say this to the industry -- I have just been dealing for several months with the paper industry and the chlorine industry on this mercury crisis. While these companies may have thought that they had their effluent problems licked, along came some bright young guys who found some very small amounts of material in there that everyone certainly felt was significant.

Now, I think this is the kind of thing with which we are going to be faced. I don't think this is industry alone, sir, but also regulatory agencies, because we have to respond so people will get the kind of environment and pollution control that we are developing. I think the time has come -- and I am not speaking of this is relationship necessarily to this conference -- when we are really going to have to think in terms of an essentially closed system including disposal of the leadoff or blowdown if we are going to be home free. I think we are coming to that in some industries, and we are getting to that more and more.

The difficulty is, I suspect, you may be at the end of the spectrum of using a heck of a lot of water with not enough material in it. I know I have been in this business for 25 years. I tell the people here, too, time after time, when we went out and looked at a pollution situation, when I found that there was cooling water, I felt we were home free.

As a matter of fact, if you look at the list of all of the companies we have proceeded against through the years -- and you know we have been pretty active -- you will find that until recently practically no power companies have been on that list. So our companies discharging heat has not been the problem until we found the causal relationship between discharge and damage. But I suspect as we are getting more refined and at least have programs to deal with the gross pollutants which we had before, there is going to be more and more emphasis on aspects of discharges which we just didn't consider before.

And I don't know that the industry has a different problem than we have. But I really do think, gentlemen, we have to sit down and try to think this through or work this through together and see where we go from here, because otherwise we are always going to be faced with something such as is facing us now.

MR. BURSTEIN: I am encouraged and I agree with you wholeheartedly, sir.

Let me say that the electric power industry has no desire to discharge heat. It is ridiculous for us and a small company like Wisconsin Electric to pay $50 million for its annual fuel bill and then dump $35 million of it into Lake Michigan. We know of no other way of doing it at the moment. But in time if we are more successful in selling steam heat, as we are trying to do in some central areas, or in a year-round agriculture, fishery business, or some of the other attempts to utilize this low level material, this very, valuable resource, we will both accomplish the same ends.

MR. STEIN: Are there any other comments or questions?

MR. MACKIE: Mr. Burstein, both you and Mr. James and a number of other representatives of the industry at this meeting have indicated that if adverse environmental effects are identified after a plant has been in operation for sometime that the industry stands pretty much committed at the time. Actually from a practical point of view -- and this was borne out in some of the testimony the other day --it would appear that at least in some cases the only real alternative would be to reduce power production. So it would seem to me that insofar as new plants are concerned that initial engineering plans should provide for some of these alternatives right at the outset.

Now, would you comment on that?

MR. BURSTEIN: Yes, I wish it were as simple as that, sir.

But, again, as you know, for example, the exhaust end of the steam turbines are designed with a particular size capacity, a certain quantity of steam at a certain volume. If we design it to operate on a cooling pond or a cooling lake or a cooling tower, be it dry or wet, we will find that this will reject more heat in a once-through system than some other design and will be defeating the initial opportunity by adding considerably more into the once-through system now in order to be able to utilize it without a reduction in capacity later.

I think these are compromises we will have to face and pay for. I don't think there is a universal steam turbine or a universal system that can go anywhere and serve any purpose. But if, for example, my infrared photographs are pertinent, one of the solutions may be to put a dike around that portion of Lake Michigan, that half square mile -- if that is the place it is -- and if we are concerned about letting this effect get somewhere else.

I might also comment on this overlapping plume theory. As you know from Wisconsin, sir, the Kewaunee plant is 4 and a half miles from the Point Beach plant, and there has been some concern that these plumes are so large that they overlap. For our own selfish purpose, we don't want at Kewaunee or Point Beach to induce the hot water from the other guy's plant. It would reduce our efficiency, would make our temperature rises considerably higher, and so we have already looked at this overlapping plume idea -- if you want to call it -- just from a practical operating point of view and we find there is sufficient -- more than ample -- under all the predictable weather and wind conditions to avail that. We couldn't tolerate a 40- or 50-degree temperature rise for the same reason. I think the maximum is closer to 30, again, for optimization of the turbine generator.

MR. MACKIE: I think perhaps you have added to my concern rather than detracted from it.

MR. STEIN: You know, Mr. Mackie, the biggest thing we have going for us now, I think, from practical effects in getting dispersion of heated water from the powerplants is the fact that if they put it too close to the water intake, they are taking in their own hot water, and they are decreasing their own efficiency. We have had that complication.

MR. BURSTEIN: I think you are also familiar, sir, that we have on rivers both discharges and intakes within a couple hundred feet of each other. How do they work?

MR. STEIN: You know better than I do.

MR. BURSTEIN: Surface cooling.

MR. STEIN: I know, but you are trying to avoid it when you can.

Are there any other questions or comments?

If not, thank you very much, Mr. Burstein.

Mr. Petersen.

O. K. Petersen

MR. PETERSEN: Mr. Chairman and conferees, the statement by Mr. Burstein on behalf of Wisconsin Electric Power Company was the last electric utility presentation so far as I know. I would remind you again that each company's statement was independent of the others and my function, except for being a representative of Consumers Power Company, was to aid in coordinating the time and order of appearances for the benefit of the conferees and those present to appear.

And, lastly, we would appreciate having placed on the record the name of the individual to contact to obtain the data behind the "white paper."

MR. STEIN: Oh, it will be right up. That is why I want you to wait.

At the conference, the conferees asked that the people who prepared the "white paper" -- and the man in point is Mr. Yates Barber, and we prevailed on him to stay, and I suggest that the industry representative stay so he can make his comment.

Yates, will you come up and make any remarks you wish to?

Now, there are two parts to that "white paper." Let me make this clear. I don't want to confuse you with the bureaucracy.

On the Fish and Wildlife part you get in touch with Mr. Yates Barber. On the other part, prepared in Corvallis, Mr. Tichenor or Howard Zar can give you this, and if you feel that you don't want to do this, of course, you can get in touch with any one of our regional offices and they will direct it to the party.

Mr. Barber.

MR. BARBER: Thank you, Mr. Chairman.

Mr. Chairman, honored conferees, ladies and gentlemen. I am very happy to be back here today to make this response to the papers that have been presented by the electric power industry. We were asked to respond to the paper by Dr. Pritchard and others.

MR. STEIN: Before you start, may I make one announcement? I am sorry to break in. I think tomorrow when we are going to have municipalities come here may be a relatively light day, and the reason I want to make this announcement is because some of you people may leave before the end, so if there are any public people who want to make a statement, it may be advisable for them to check in tomorrow and we may be able to put them on.

Mr. Barber.

MR. BARBER: Thank you.

We have had, of course, but the one day to review

Dr. Pritchard's paper. Because we have wanted to be here to hear the other papers, we have not been able to prepare any written statement for distribution. I am very sorry about this, but you understand the time limitations.

If we may, Mr. Chairman, we would like to direct some comments at some of the papers that have been presented by consultants to the power industry. This is by no means an effort to cover everything point by point, but there are some important points that we would like to identify for you if we may.

To begin with, if I may, I would like to identify the so-called "anonymous authors" of the Fish and Wildlife Service "white paper." This report was done by a large number of individuals, and we are going to ask each one of them to respond to certain points which are his specialty a little bit later, in just a few minutes. Meanwhile, I would like to ask these individuals to stand and be identified.

We have, first, Mr. John Carr, who is Acting Director of the Great Lake Fishery Laboratory, U. S. Bureau of Commercial Fisheries at Ann Arbor, Michigan.

We have Dr. Peter Colby of the same staff.

Mr. Thomas Edsall of the Ann Arbor Laboratory.

Mr. Kenneth Roberts of the Bureau of

Commercial Fisheries, formerly in the regional office at Ann Arbor, and currently in the Washington office.

Then we had able assistance from two individuals in the Federal Water Quality Administration. They are Dr. Charles Powers from the National Eutrophication Laboratory at Corvallis, Oregon, and Mr. Richard Callaway, who is from the National Thermal Pollution Laboratory in Corvallis.

I would like to review that there have been in addition to these men perhaps a dozen others who have assisted. Several of these are from the Ann Arbor Laboratory, which has done the principal biological work. The section dealing with thermal influence was done by the Corvallis Laboratory.

During the course of the events, there were a number of comments offered as to the qualifications and the lack of field experience that might have been exhibited by some of the authors of this paper. Just so that we do fully understand the scientific qualifications and the degree of experience and professionalism that we employ, I would like to note that the seven professional staff members from Ann Arbor who participated in authoring this report have all combined an -- I think impressive -- total of 107 years' experience in professional fishery work. Most of it is in the Great Lakes; much of it is in Lake Michigan. In the last 18 years there have been more than 6000 man days in the field in vessels in Lake Michigan alone, a good deal of which was by these particular individuals.

There were a few other people like myself, that were engaged in preparing this report, and we combine a total of about 50 years' experience in environmental and ecological matters, including the evaluation of the effects of water development projects on the environment, particularly effects of powerplants along with dams, navigational projects and other such developments.

Now, before I start asking these men to give you their comments, I would like to call your attention to a few basic concepts that were involved in the preparation of our basic biological report entitled "Physical and Ecological Effects of Waste Heat on Lake Michigan."

The reason I want to do this is because the engineering fraternity frequently tends to deal in terms of averages. This is perfectly valid. It is perfectly good. We do, too. But, just as when a dam is designed you must recognize the average and peak flows, in biology you must recognize the extremes. Therefore, in making our evaluation of the impact of waste heat in the lake, we have paid particular attention to the extreme conditions that are occasionally induced by climate or other reasons from the waste heat discharges in areas of the lake.

I think there is a very important point that I want to make here. I will put it simply. Our evaluation is based on the fact that we do not feel you have to kill a fish more than once to establish damage. Basically what I mean by this is that impacts in a river or lake which eliminate a population of fish, whether it be the adults, the juveniles, the larvae, the eggs and spawn, or simply causes the adult female to resorb her spawn products because of a change in temperature, are damaging effects. If such impacts are induced periodically in an area, it may be sufficient to control the population of that particular species.

I want to emphasize, of course, that in addition to these immediate effects, that we are very much interested in the long-term and indirect effects, which may not appear for quite a long time yet to come.

Now, I would like to call upon Mr. John Carr to offer his comments relative to the paper by Dr. Pritchard and others.

Mr. Chairman, would you like to have these men come up here?

MR. STEIN: Yes, I think that would be better.

MR. BARBER: Each of them will speak briefly, and I would also like to ask them to state for you their professional experience, training, and qualifications as individuals.

MR. STEIN: Do you think it would be better, Mr. Barber, if each of them spoke briefly and we would give them a chance to ask them questions one at a time?

MR. BARBER: If we may, I think it might be better if we completed this, since most of these will be brief, then I would like to make a few summary remarks.

MR. STEIN: We will do this.

MR. BARBER: Yes. Now, let me say this: Dr. Tichenor's comments relative to the feasibility report will be made individually after I have completed our comments on the biological report.

MR. STEIN: All right.

STATEMENT OF JOHN F. CARR, CHIEF, ENVIRONMENTAL RESEARCH PROGRAM, FISH AND WILDLIFE SERVICE, U. S. DEPARTMENT OF THE INTERIOR, ANN ARBOR, MICHIGAN

MR. CARR: I am John Carr, Chief, Environmental Research Program of the Great Lakes Fishing Lab, Fish and Wildlife Service. Today I am in the Bureau of Commercial Fisheries, tomorrow I will be in the Bureau of

Sport Fisheries and Wildlife.

I have a master's degree from Michigan State University in fish and limnology. I have spent the last 10 years actively engaged in environmental study in all of the Great Lakes.

Most of my remarks are going to be directed to questions raised -- some of them -- I think most of them -- by Mr. Currie, and I want to begin by rereading the introduction to the "white paper."

"There is reason for concern about potential serious ecological damage to Lake Michigan as a result of discharge of industrial and municipal waste heat. At the predicted rate of increase, the waste heat load rejected to Lake Michigan by the year 2000 would be more than 10 times the present load. The source of most of the waste heat will be the power industry. Required power capacity has been doubling each decade and there is no sign that this rate will diminish."

I don't think that has been disputed in the three days of hearings.

"Everyone concerned with the problem agrees that not enough is known about the ecological effects of massive heated effluents and that a great deal of research is needed on this problem. Unfortunately, the information is needed now; since it is not available, however, interim standards must be set for Lake Michigan on the basis of existing knowledge.

"The purpose of the present report is to present the available evidence that substantiates this concern. The evidence reasonably demonstrates that heat addition, as presently proposed, is an essentially cumulative problem that would contribute to inshore eutrophication and be intolerable from the fish and wildlife standpoint by the year 2000."

There has been some question about "cumulative." By this, we simply mean that as the years go on, approaching the year 2000, there are more and more discharges into the lake, more B.t.u.'s, more cubic feet, or what-have-you. We didn't mean that the lake continually warms up. I think we make the statement that the lake always returns to winter temperatures.

"Therefore, it is in the public interest to stop this process now, rather than attempt the difficult task of correcting or reversing it after it has occurred."

The power industry has emphasized over and over that they can do things before they design, but it is difficult after they are constructed.

"On the basis of the evidence presented herein,

J. F. Carr

this Department supports stringent standards for Lake Michigan, and concludes that no significant amounts of waste heat should be discharged into Lake Michigan."

And this was covered very well in the last paper.

One of the questions that has arisen is the selection of the zones, the size of the zones and the depth. The inshore zone, designated at zero to 100 feet, was selected because this depth usually includes all of the epilimnetic water and the thermocline when it is present. It is an ecologically distinct zone. When there is a thermocline present, it is usually 100 feet or shallower. The beach water zone, zero to 30 feet, was selected because there is usually complete vertical mixing in this zone. It is rare to find a horizontal gradient in this beach zone. From the biological standpoint, these two zones are ecologically unique. That is why they were selected.

The importance of the shallow water is: The shallow waters are most important from an ecological point of view. It is far more productive per unit area than what is beyond the photic zone area, and we gave some examples in the "white paper" why this is so. Every ecology textbook also discusses it.

According to all reports presented thus far, including Dr. Pritchard's, the thermal plume from all currently proposed plants will be in this zone. The slides from the Willow Run laboratory, that we saw this morning illustrates this very well. Also I don't think it was mentioned, but infrared imagery only shows the surface temperature to a depth of a few molecules. We had some arguments, discussions, about the volume of the inshore zone. We are talking about 4 percent included in 100 feet contour and only four-tenths of a percent to a 30-foot contour. We think this is a significant statistic, and I hope to show why.

The surface of the zone inside the thermal barrier or bar we realize is level. Dr. Pritchard questioned us on our belief here. We do believe in water seeking its own level. But mixing between the inshore waters and the offshore waters is inhibited in the spring due to this thermal barrier. We prefer to call it a thermal barrier because the thermal bar has developed with a specific definition in that 4-degree water or water of maximum density must be present with water of less density on both sides. Quite often in Lake Michigan this is not necessarily true, but there is a horizontal gradient, which would be a barrier to mixing. I think the people talking today realize that this is so, but they skirted it.

The interface between these 2 zones is readily visible to the naked eye, because of the buildup of suspended matters on the inshore side. The secchi disk readings are three to four times greater on the lakeward side of this thermal bar than on the inside of the bar. The thermal bar is essentially a thermocline turned on edge, and if Dr. Ayers or Dr. Pritchard could convince me there is a great amount of mixing between the two zones, then the people at Lake Erie could quit worrying about oxygen pollution from the bottom waters of the central basin. There is a barrier to mixing between these two zones.

Now, during the period that the thermal barrier is present, the effective volume as far, as the entire lake is concerned, is reduced. I think Dr. Mortimer will present more information on this tomorrow or the next day.

One other statistic that has not been brought out: The 91,000 cubic feet per second predicted for the year 2000 is one and a half times the outflow of Lake Michigan based on the computations of Dr. Ayers. I think it has already been explained why we used the date of the year 2000. We thought we would go to the point where damage could be shown and try to work backwards from that point. In the year 2000, we are thoroughly convinced there will be a problem if projections hold true. The thermal bar slide showed by the Willow Run Laboratory was a very impressive slide, but very deceptive. The slide showed that the thermal bar was a good ways offshore -- it looked like several miles. Even the thermal bar is much closer inshore and the Grand River would appear much larger in proportion to this.

Another thing, most of the studies we have heard about have not concerned fish. The only one I have heard about -- and I may be wrong on this -- was a gill net had to be set 4 times a year by the State of Michigan. Four times a year would not even detect, I would say, a decrease in the population of 50 percent each year; fish are so variable.

Dr. Ayers' slides show considerable bottom influence on the Waukegan plume. I understood from Dr. Pritchard's report that this probably would not be true. Also from Dr. Ayer's slides I saw almost no tendency for this water to flow, and you can look at his paper. Damage to fish is difficult to measure. It is so difficult that it would probably take 1 or 2 vessels fulltime with full crews to show a change each year of 10 percent or greater. What we have been dealing with in the Great Lakes in the last few years is a slow decline, and suddenly we have no fish at all. We have lost, I think, 3 species of fish completely in Lake Michigan in the last 20 years.

I am disappointed that some of our colleagues are accusing us of being armchair biologists because there are several wives at Ann Arbor that wish to heck we were.

In conclusion, I feel that the testimony of Dr. Ayers, Pritchard, Raney, Robertson, and Dr. Lee all support the thesis that damage can occur as a result of powerplants on Lake Michigan, using once-through cooling, because all of these people suggested ways of minimizing the damage by such things as proper site selection, design of intake, design of outfall, or manipulation of the operation.

Thank you.

MR. STEIN: Mr. Carr, I have talked to Mr. Barber, and in listening to your statement because of a possible crucial impact on the deliberations and the technical nature of this, I think we are going to change the procedure and ask for questions now, so we can keep it in one place in the record, because I hadn't realized these comments would be that extensive or that technical.

Are there any comments from the conferees?

Mr. Currie.

MR. CURRIE: Do you have any comments about the dye test run by Dr. Pritchard to determine the extent of blocking at the thermal barrier?

MR. CARR: Yes, and I think Dr. Lee's comment and Dr. Ayers' comment on measuring total dissolved solids -- this zone is large -- I think the measurement techniques used as far as dilution is concerned, are such that the buildup in total dissolved solids would not occur to the point where one could measure it. You have to be in an area where you have an input of total dissolved solids and it has to be a river.

With the dye you are talking about -- at the thermal bar -- there is a terrific downwelling of water, and I think it is just simply diluted. He did not show that it crossed the thermal bar. The very name to me indicates lack of exchange, and how you could have temperature gradients as great as you had, if you had complete mixing is beyond me.

MR. CURRIE: Do you have any views on Dr. Pritchard's notion about the limited residence time of any particular molecule or organism in the thermal plume? I take it that this is a very important part of the thesis of the Commonwealth Edison Company.

MR. CARR: I don't feel that I could comment on that. That is out of my area. I would have to rely on his statement.

MR. CURRIE: Do you have any studies that show an increase in the eutrophication -- field studies --

MR. CARR: Due to heated --

MR. CURRIE: -- due to heated discharges of the type, of the size that we are talking about on Lake Michigan? We have had some limited preliminary studies presented by utility companies that purport to show that so far they have been unable to find any eutrophication or indeed other kinds of biological damage. Do you have any conflicting data?

MR. CARR: No, sir.

MR. CURRIE: What is the closest thing to relevant data that you have? I take it there must be some studies somewhere that someone has conducted that show some adverse effects of heat on something, and that is the basis of your recommendations.

MR. CARR: If you are talking about fish, yes, but you were asking about eutrophication. I am not even sure what the term means. It had several definitions here, most of which I disagree with. Eutrophication can be a very desirable thing. If you are talking about the growth of algae, we do not have any studies. If the inshore zone inside this thermal barrier is visible because of the increase of the algae on the inside part -- the warmer part -- if this is due to the increased heat in this area, then there is a good case to show that you have a buildup of algae. I am not saying it is.

MR. STEIN: Mr. Miller.

MR. MILLER: John, do you have any indication of critical areas around Lake Michigan where one or two degrees would be very critical? Can you identify these areas?

MR. CARR: A report at the Milwaukee hearing of this committee that some recent study by Canadians have found some rather discrete spawning areas in Lake Huron in 3 to 5 feet of water and it was felt if this spawning stock were wiped out it would not be replaced -- going from that discovery to Lake Michigan, I suppose there are also stocks in Lake Michigan that could be affected. These have not been identified.

MR. STEIN: Mr. Purdy.

MR. PURDY: John, you have seemed in your additional remarks here to focus upon the year 2000 as being a time when you could with certainty predict the damage. During the last several days we have heard a great deal of testimony with respect to the problems of backfitting existing powerplants, and that you can treat this problem in a different fashion on powerplants yet to be constructed. But yet in your report -- and you repeated this, I believe, in the earlier remarks -- but anyhow in the report it reaches a conclusion that no significant heat input should be made to Lake Michigan. I am not sure what "significant" is yet, but you mean a significant addition over and above what we have now? Or do we have to cut back what we have now?

MR. CARR: From a fishery standpoint, I think some of the fellows that follow me will maybe answer this a little more. I think any plant that pulls in water, takes it through a turbine, heats it, dumps it out, causes damage. Whether that is significant or not, I don't think I am to be the judge of it. I don't know that I can answer it any more than that, Ralph.

MR. STEIN: Are there any other comments or questions from the panel? Are there any from the audience?

MR. FETTEROLF: John, did I understand you to say that the increases in turbidity inside the thermal bar may be plankton?

MR. CARR: Yes, I think they are plankton.

MR. FETTEROLF: And if they are plankton, you would relate this to the temperature?

MR. CARR: No.

MR. FETTEROLF: All right. I misunderstood you then.

MR. CARR: I said it could be a factor.

MR. STEIN: Mr. Bane.

MR. BANE: Mr. Carr, in connection with your statement about the sensitive area in Lake Huron you said that there were likely to be similar areas in Lake Michigan, but that they had not been identified. Can they be identified with proper environmental studies?

MR. CARR: I think so, yes.

MR. BANE: And could be identified before a powerplant was sited in that area?

MR. CARR: I think so, yes.

MR. BANE: Thank you.

MR. STEIN: Are there any other comments or questions from the audience?

Yes, come on up. I take it if anyone -- and I say this generally -- wants to make a statement, try to get close to the mike, and we will save time.

DR. McWHINNIE: I am Mary Alice McWhinnie. I am glad to see you again. I couldn't place why I knew you before.

MR. STEIN: Can you hear in the back?

... Cries of "No" ...

DR. McWHINNIE: Somewhere in your report -- and I cannot recall it verbatim -- it goes that because of a thermal increment infirmity, young fishes will develop faster before their food organisms are available. I assume both populations are exposed to the same thermal increment -- the young fishes, the fry, the just early post-embryonic stages. Accordingly, so too will not the zooplankton experience the same thermal increment? Why would it be that the fishes are ready for feeding in advance of when the zooplankton would not yet be available?

MR. CARR: There will be more comments later on this. I would just say that we are dealing with eggs on the bottom in the influence of the thermal plume. The food organisms are not in the influence of the thermal plume. When the eggs hatch out they become part of the entire lake, not rooted to one spot.

DR. McWHINNIE: So this becomes, then, a matter of the geometry of the plume relative to the two populations, and do we not see that the thermal plume, when released in shallow water, does involve most of the water column?

MR. CARR: The plankton may originate miles from where the fishes are hatching. You heat up the egg area, they hatch sooner, but you have not influenced the plankton in the lake. The whole lake is not heated up, only that area.

DR. McWHINNIE: This is true, but then you are presenting this as a -- I will say -- theoretical circumstance of a special difference without, if you will, the true evidence for where those currents are going either for the young fishes, which are also subject to currents, as are the zooplankton or phytoplankton.

MR. CARR: Could you wait for a little better explanation from Dr. Colby with some data on this and the effects of a few degrees on egg incubation?

DR. McWHINNIE: Yes, thank you.

MR. STEIN: Thank you.

Are there any further questions?

MR. CURRIE: I have one more.

There was a suggestion, I think, in one of the power company papers that an increase in heat could affect the species distribution of algae but not the total amount of algae. Would you agree with that?

MR. CARR: Yes. If there are just so many nutrients available, and that is all that can be used, the heat can speed up the process, but it can't produce more than you have the building blocks for.

MR. CURRIE: Then suppose you have a large amount of nutrients present, might then the addition of heat increase the percentage of such available nutrients which are in fact utilized by algae?

MR. CARR: Would you repeat that?

MR. CURRIE: If you have an adequate supply of nutrients, a large supply of nutrients, might the addition of heat increase the proportion of such available nutrients which are used by algae and therefore increase the total algae production?

MR. CARR: If heat is a limiting factor, nutrients, by adding heat, you would get a greater productivity, yes.

MR. CURRIE: And are there situations in which heat can be a limiting factor in the total algal production?

MR. CARR: Yes, but I am not being specific to Lake Michigan. In general, yes.

MR. STEIN: Any other comments?

MR. FETTEROLF: When you said you would get greater productivity, did you mean standing crop or productivity?

MR. CARR: Which one, the latter supposition?

MR. FETTEROLF: The first one.

MR. CARR: The first one where a limited amount --

MR. FETTEROLF: If you had an excess amount of nutrients, the question was: Will, then, the addition of heat increase the amount of algae and you, I believe, said it would increase the productivity, and this might be interpreted as the standing crop.

MR. CARR: No, if heat is the limiting factor and there is adequate nutrient and you add heat, you would increase productivity. I don't know about the standing crop.

MR. PETERSEN: I regret that the scientists who would be best able to ask questions pertaining to this matter have left without awareness that this testimony would be presented. Accordingly I hope you will follow through with a mere lawyer trying to ascertain what is happening here, But I think if I understand you correctly that you challenge the findings of those who have made thermal plume studies that they float.

MR. CARR: No, we have heard testimony over the past few days about how the thermal plume floats has very little effect on the bottom. I was ready to believe this. I was convinced until Dr. Ayers showed his slides. From his slides, there is no evidence that the plume that he studied has any tendency to float until it gets less than 2 degrees Delta T. If I am misinterpreting the slides and the paper, then --

MR. PETERSEN: Then, the only evidence upon which you made that statement was your interpretation of those slides which were prepared by Dr. Ayers.

MR. CARR: That is the only ones I referred to, yes.

MR. PETERSEN: And have you identified any fish eggs in the vicinity of any present or proposed thermal plume from an electric power generating station in Lake Michigan which might be affected?

MR. CARR: I don't know that we have studied this. We have not deliberately gone out to look at any thermal plumes in the Great Lakes.

MR. PETERSEN: Do you have any challenge or question pertaining to the testimony which you have heard, at least as to the eastern shore of Lake Michigan, as to there being a relatively barren area insofar as benthic organisms are concerned due to the grinding of sand caused by wave action?

MR. CARR: No, I agree with this.

MR. PETERSEN: Would it be correct to assume that if benthic organisms could not survive such grinding that fish eggs would be similarly affected?

MR. CARR: No, I don't think so.

MR. PETERSEN: Then, it would be appropriate to believe that fish eggs could be deposited on this grinding sand and they would survive and produce viable fish populations in that area? I am just trying to get this straight. I am not challenging you.

MR. CARR: Many of the fish in this inshore zone, particularly perch, the eggs don't necessarily lay on the bottom.

MR. PETERSEN: What do those fish eggs do, then, please?

MR. CARR: They usually -- usually they are an envelope, and they are usually wrapped around some projection above the bottom, whether it is a plant or something like this.

MR. PETERSEN: Well, in the case of a sand bottom where we have no projections, other than the experimental stations of various scientists checking the plume, we wouldn't expect to find, then, perch eggs?

MR. CARR: Right.

MR. PETERSEN: Now, as to this thermal barrier or bar -- I think you used both terms, and I am not well enough acquainted with the terms to be able to precisely identify which is the correct one, if one of them was more correct than the other -- it is my understanding from reading a couple of these papers, and some discussion, that this bar forms in the spring and moves rather consistently outward into the lake until eventually it disappears. Is that essentially correct?

MR. CARR: Yes.

MR. PETERSEN: Is that a constant moving factor and about what rate does it move? Could you give us any idea of that?

MR. CARR: I think in perhaps Figure 1 we have an average of about sometime around April 1 or April 15 to June 1, in the neighborhood of 45 days, when it is first detected until it becomes a thermocline.

MR. PETERSEN: Have you or those others who prepared the paper made a particular study of this phenomenon? Have you followed it out day by day to ascertain its movement and its behavior other than the -- let me say -- just disk observations which you described earlier?

MR. CARR: No. If you were fishing in Lake Michigan in the springtime, particularly if you are going coho fishing in April or May, you fish inside this bar, if you want to catch a fish. If you fish outside, you won't catch coho; neither if you are fishing commercially for alewife. We find that in this regard too we do locate the position, but we do not measure its movement.

MR. PETERSEN: Well, have you any figures that you could give us to aid us in determining what is going on as to its relative position of movement and the relative volume of water inside the plume day by day as it moves outward? I take it from the fact that it moves outward there has to be some passage of water one way or the other between the two, otherwise it would act as a dike.

MR. CARR: Yes, water does seek its own level, if that is what you mean. Its temperature, according to the people of the University of Toronto who studied this in Lake Ontario -- the position of the thermal bar in relative relation to the shore is dependent on the offshore temperatures of the mass of water lakeward. If you add temperature particularly to the inshore area, you increase the gradient across the thermal bar, but you do not increase its distance from shore. That is determined by the warming trends on the inside -- the lakeward side of the bar.

MR. PETERSEN: Well, could you give us an idea of how fast that moves outward?

MR. CARR: It begins some distance offshore, less than five miles, sometime around the 15th of April, on the average. By June 1st, it is no longer present.

MR. PETERSEN: How far up does this move?

MR. CARR: In the first part of June, I would say it could be as much as 15 miles offshore.

MR. PETERSEN: The way you answered that led me to believe it was what we might term as a guesstimate. Have you any --

MR. CARR: Yes, we have a report based on the temperatures of 54 and 55 in Lake Michigan, in which we have 55 crossings of the lake, three or four a month. From these you could determine its position.

MR. PETERSEN: Did you do that?

MR. CARR: Yes.

MR. PETERSEN: During your studies?

MR. CARR: The two papers by Church referred to in here - Dr. Mortimer, I think, will present the data on Friday to show some of the effects here. He also refers to Church.

Most of the information, most of the study on thermal bar and thermal bar phenomena has been documented on Lake Ontario because it is so much more pronounced on that lake.

MR. PETERSEN: Once again, you will have to pardon me as being a lawyer, not a scientist in this matter, but if it is so much more pronounced on the other lake, would that not be some indication that its behavior might be different on the two lakes?

MR. CARR: It is very definitely different on each of the lakes in which it is found -- on every lake on which it is found, and probably varies with season and every year it is different.

MR. PETERSEN: And your real studies of this were on Lake Ontario rather than Lake Michigan?

MR. CARR: No. I didn't say that. The studies that we have -- I referred to -- was Church, the paper that is in press, by Carr, Moffett, and Gannon, and some work by Dr. Mortimer.

MR. PETERSEN: Very briefly, then, to try and conclude this, you, as I understand it, challenged the testimony of Dr. Pritchard as to mixing. Would that be properly stated?

MR. CARR: Yes. It was unfortunate that we didn't get a chance to question the witnesses. It is unfortunate that some of the questions concerning our paper were not asked at the time that the paper was presented. Dr. Pritchard left me with the impression -- and I think he left the audience with the impression -- that the thermal bar is no barrier to mixing, that there is no restriction between the movement of water from the inshore area to the offshore area during the period in which the bar is there. Is that your opinion of what he said?

MR. PETERSEN: I would just as soon ask the questions if you don't mind.

MR. CARR: Well, I will speak for myself. This is the opinion he left with me. If that is what he is saying, I am questioning -- I say that is not true.

MR. PETERSEN: There are various things, I understand -- what you are challenging, then, is that it does present some barrier, but it is not a complete lack of barrier is what you are saying?

MR. CARR: No, it is not a complete lack of barrier.

MR. PETERSEN: But I do get, then, from what you have just said that you would agree that there is mixing across that barrier.

MR. CARR: Yes, there is mixing across the barrier. There is mixing through the thermocline in Lake Erie. Dr. Pritchard, I believe, said -- although I don't think he meant it the way it came out -- that the thermal barrier enhances mixing. It may enhance mixing inshore; it may enhance mixing on both sides of it, but it does not enhance mixing from the inside to the outside.

MR. PETERSEN: Now, to return to the question I asked you: If there is some mixing across the thermal barrier, have you quantified that in terms of mathematics, or have you performed any studies as to the extent of such mixing?

MR. CARR: No.

MR. PETERSEN: I think I have no further questions at this time. Thank you.

MR. STEIN: Thank you.

Are there any -- come on up. While you are coming up, I would like to make a couple of procedural points clear if I may. One, that after the Federal report as well as any other, I believe we offered full opportunity for questioning. We announced relatively early yesterday that at the request, I believe, of Mr. Currie that Mr. Barber and his group would provide this information and, of course, these people are open to questioning by whoever is here. I know we have the occupational problem that lawyers also have to be around when sometimes other people aren't here. Perhaps -- let me give a personal aside. You see how difficult it is sometimes for me to get a report out from some scientific people, particularly when they are at a different agency than mine and all I have is my persuasive powers to get them to do it.

MR. KEANE: My name is Steven Keane. That is spelled K-e-a-n-e, and I am a scientist of the nature of Mr. Bane and Mr. Petersen; namely, I am an attorney for Wisconsin Public Service Corporation, for further identification, and I would just like a little information.

Did you mention, I think, at the conclusion of your original presentation that the fish species in Lake Michigan -- that three of the species in Lake Michigan had disappeared in the course of the past number of years? Are we to understand from that that that bore any relation to the thermal conditions in Lake Michigan?

MR. CARR: It bore no relation whatsoever, and I was merely using it as an example of what has happened in the Great Lakes, in which we lose species after species, population after population, with no one to blame.

MR. KEANE: Fine. This was a good clarifying question then.

One further question in that respect: You have been here during the past several days when Drs. Raney, Pritchard, and so forth, testified, and described the type of examinations and surveys that they had made in connection with thermal pollution from the various outfalls of electrical generating stations. Have you yourself, sir, to any degree, made that kind of a survey which could in any way for us describe by picture or otherwise the nature of plumes by which you disagree with their contentions as to what they are, or by which you might indicate that you believe that their conclusions that the harm to fish life is insignificant could be challenged? Have you made any such surveys?

MR. CARR: I have not personally made these surveys, and I think what he said was mostly in agreement with what they were saying.

MR. KEANE: Very good. Thank you.

MR. STEIN: Are there any other questions?

MR. HIPKE: My name is Jack Hipke from Wisconsin Power and Light.

I just wanted to ask a question. You say you cannot determine the mineral content in the two zones that are separated by the thermal barrier due to dilution. You also stated that there is a definite plankton concentration on one side of the thermal barrier. Did you do any plankton counts on the water on the two sides of this barrier?

MR. CARR: I did not.

MR. HIPKE: How about bacterial count, since this is supposedly an area of concentration of all nutrients, wouldn't this -- this would be some indication if there was a passage of water from one barrier to the other?

MR. CARR: I think the statement was made that any river discharge into this inshore zone during the time the thermal bar was there would tend to keep most of the nutrients inside this thermal bar and would prevent mixing.

The only data I can cite on that were some studies done in 1965 in the vicinity of Ludington, in which phosphorus and nitrogen was higher in this inshore zone than the offshore zone, this was due to a river on the opposite side of the lake. This was not true. You could not measure this.

MR. HIPKE: Well, it seemed like this would be a very good indication, once and for all, if you could find out if there was either a higher plankton count or a bacterial count on one side of the barrier or not.

MR. CARR: The statistic I cited was about four times better visibility on one side than on the other.

MR. HIPKE: You really didn't actually take a plankton count so you can't really say it was the plankton that caused it.

MR. CARR: I can definitely say it was plankton causing it, yes. I didn't count them.

MR. HIPKE: And there was some things in the "white paper" on Clostridium botulinum that bacteria are supposed to increase with temperature in the area of the plume. Since these are classified as anaerobic bacteria would you like to comment if there would be a decrease in bacteria in this zone or supposedly an increase?

MR. CARR: Do you have a statement from Dr. Graikoski on this?

MR. BARBER: Yes, I do.

MR. STEIN: Why don't we wait -- you are going to make a presentation, Mr. Roberts, aren't you?

MR. ROBERTS: I am now.

MR. CARR: Yes.

MR. STEIN: Can you wait on that question?

MR. HIPKE: Yes, I have one more question as far as the dispersion of the plume. I don't know if this is one of your questions or not, but from the 1 million kilowatt nuclear plant how did you determine the dispersion at 364-square-mile area back down to ambient?

MR. CARR: Would you save that question for Mr. Roberts, please?

MR. HIPKE: Right, thank you.

MR. CURRIE: I have one more question, Mr. Chairman.

It is prompted by a question that I believe was asked by Mr. Fetterolf a moment ago, and he was asking whether heat can be a limiting factor in the production of algae. He attempted, I think, to distinguish between productivity, on the one hand, and a standing crop, on the other, and I would like a clarification as to what is meant by that if I could have it.

MR. CARR: A standing crop is the amount of organisms present at any one time. Productivity is the rate at which they are renewed.

MR. CURRIE: Well, if there is no increase in the standing crop but there is an increase in productivity, have we made the problem of algae more serious?

MR. CARR: Well, it is usually the standing crop that most people complain about, if you are talking about that. If you are talking about the rainout of plankton, perhaps the productivity would be the thing we are concerned with. It is a high standing crop that people see.

MR. BROUGH: My name is John Brough. Did I understand --

MR. STEIN: Do you want to identify yourself further, whom you represent?

MR. BROUGH: Well, I work for Inland Steel Company.

Did I understand you to say that when you were discussing eutrophication that eutrophication can be beneficial? I thought I heard you say this. I was interested to clarify it.

MR. CARR: Yes.

MR. BROUGH: Would you elaborate a little more on this, because I got the impression from reading the "white paper" that the increasing eutrophication was bad, and I just would like to know about that.

MR. CARR: If you are a catfish farmer in Arkansas, you try to have as eutrophic a pond as possible. If you want to go swimming in a body of water, you want to try to have as oligotrophic a pond as possible. So it depends on your use of waters, whether it is desirable or not.

MR. BROUGH: In the context that you were talking about in the "white paper" is that eutrophication good or bad?

MR. CARR: This is based on what the people appear to prefer, and everything I have heard at every conference they prefer clean water with no slimy algae on the beaches.

MR. BROUGH: I see. Thank you.

MR. CARR: Undesirable.

MR. STEIN: Mr. Brough, I knew where you worked, I just wanted to see if you were still working there.

Any other comments or questions? If not, thank you very much. I think the record on this is going to be very valuable, and I think we are really getting pretty precise on the issues.

MR. CARR: Excuse me, may I introduce the next speaker?

MR. STEIN: Yes, go right ahead.

MR. CARR: Next will be Dr. Peter Colby.

DR. COLBY: I am Peter J. Colby, the project leader in the Fish and Wildlife Service, studying the biology and ecology of Great Lakes fish, and one of the authors of Chapter IV of the "white paper." I received my Ph.D. in 1966 at the University of Minnesota in fisheries biology. Prior to receiving my Ph.D., I worked for five years for General Foods Corporation in research and development. I worked the past four years at the Great Lakes Fishery Laboratory conducting both laboratory and field studies.

During this hearing, there has been no evidence in the form of studies or data presented here or publications made available, which have demonstrated that fish life will not be damaged by the intakes and the hot water plumes during their critical life history stages. In contrast, our studies at the Great Lakes Fishery Laboratory and published literature cited in the"white paper" indicate that massive damage will be caused by thermal discharge predicted in the year 2000.

Another point I want to make: we have talked about lab studies. All of our lab studies cited in the "white paper" were practical studies directed to answering questions raised, but unable to be answered by field observations. Where confirmation has been attempted, the results of these lab studies have been consistent with results predicted from field observations. Studies of the early life requirements of lake herring, for instance, have yielded a predicted model for incubation times. When tested against field observations this was found to actually predict hatching time in nature when water temperatures are known.

In other words, our time-rate studies in the laboratory applied to a model have been verified by three years of research in the field. So when I say that 3.6 degrees Fahrenneit is going to shorten the incubation period by 29 days of lake herring in the lake, I feel reasonably sure that is going to happen.

In reply to Dr. Raney's studies, he made a statement yesterday that I just cannot believe. He said cold-water fishes do not use the inshore waters at least within the last 50 years. This is absolutely not true. I cannot imagine what he was thinking. He made another statement. He said that fish can swim away from an intake velocity of one-half foot per second. He didn't specify the size of the fish. This may be true for some fish. It is not true for sac fry.

To my knowledge, also, I want to add there is no intake design in use by powerplants which will prevent entrainment or damage to larval fish. If there is, I want to know about it.

And, in conclusion, it is in my opinion that regardless of which plume model is used, as long as there is an intake and a hot water discharge in the beach zone, there will be local damage to fishes and fry utilizing the beach zone. Intakes and hot water discharge covering significant areas of Lake Michigan's shoreline will destroy the lake herring and whitefish stocks in these areas, and if these species are presently depleted in these areas, this will prevent them from returning to their original distribution and abundance.

MR. STEIN: Does that conclude your statement?

DR. COLBY: That concludes my statement.

MR. STEIN: Thank you, Dr. Colby.

Are there any comments or questions?

MR. PURDY: Dr. Colby, again, you have repeated this matter of a discharge into the beach zone, and maybe we wonder how this might be accomplished in some other zone. But I don't think that is for you and I to worry about, because unless we answer this question, I think somebody will figure out how it can be done and then we will have to answer it.

And that is: Do you predict the same sort of problems if the discharge is made into the offshore waters rather than into the inshore waters or the beach zone waters?

DR. COLBY: I am not in a position to answer that. I don't know.

MR. STEIN: Are there any other comments or questions?

MR. CURRIE: Yes, one, Mr. Chairman.

You say, Dr. Colby, that there are studies that show that fish will be hurt by the discharges contemplated by the year 2000. Now, those studies are not presently in the record, are they? I think it would be helpful if they were.

DR. COLBY: Are you referring to the study of why I am saying that incubation period will be shortened?

MR. CURRIE: Well, I think you made the clear statement that although there was evidence of studies in the record that would show no harm would result from power discharges by the year 2000, you had studies that would show the opposite.

DR. COLBY: Let me qualify this. My studies show that if eggs are laying on the bottom and the temperatures are raised 3.6 degrees, over the period o: the incubation period they will hatch 29 days early. This means instead of hatching in April they will hatch in March. Now, in March, this is a hostile environment. I haven't conducted this study in Lake Michigan, and I am referring -- because we don't have the data -- I am referring to other studies -- a literature search of other studies pertinent to these fish that were conducted throughout the world. They are all cited in the paper, and the case was put together that, for instance, if these fish hatch a month early, it is my opinion that the food availability will not be there. Then I cite Einsele's paper showing the effect of density and light intensity as far as its effect on the survival of fish. I cited the German studies, which show that when they hatched their fry early they do not get survivial in lakes. For instance in Lake Constance, they had to reduce the incubation temperatures to get those fish to hatch in April so they could be available at the right time, when the plankton was available for survival.

Now, all this is in here. It is all presented.

MR. CURRIE: But I think my point is the same one I was trying to make to people from the power companies.

Both sides seemed to me to have said: Studies show that, and then they proceed with their conclusion. But they give us their conclusion, their summary of this study, their assessment of its results, without giving us the study itself, and I would be more comfortable if I could see the study.

DR. COLBY: Well, you have got the information right here, and if you want to go through and read those literature citations and all of the bibliographies you may draw the same conclusions as I. If you don't, I will debate it with you. I didn't conduct these studies; they are in the libraries. Read them. I think people should be more scholarly about these problems. You sit in the position here to make a decision. Why don't you read some of this?

MR. STEIN: You know, Dr. Colby, this works both ways. I really have to give a tremendous vote of thanks to the power industry, because they talked about the anonymity of your report, and I guess they spun you back out into the real world to talk to us. What I have been trying to do in the Government for 10 or 20 years -- and certainly since we came into the Department of Interior -- and haven't been that successful, is getting out individuals like you here today. They have been able to achieve this, and I think this is great. I would like you to meet each other. I think we are having a wonderful conference here because of this. This is a great thing, and I hope you go back and tell Gottschalk, Glasgow and Edsall what an exhilarating experience you have had. Maybe we can keep doing this.

MR. CURRIE: It seems to me that when someone comes before judges and other decision-makers and asks them to accept the position that one has adopted, one has some responsibility of presenting evidence to persuade the judge to the validity of his position.

MR. STEIN: That may be. I don't want to get into this. But the notion is what you are doing is getting an opinion here -- an opinion evidenced from an expert. We are not in a court of law; we are not dealing with evidence.

Now, as I understand it, these studies were done presumably by these other scholars. They were not done by Dr. Colby. I don't know, if we were dealing with strict rules of evidence in a court of law whether he could get those in. What he might be able to do is qualify himself as an expert and say, on the basis of his reading, he was giving us his opinion. I don't know whether you would be in accord with what we got here from this type of expert witness.

P. J. Colby

We are getting these facts out, and this is something on which the conferees are going to have to make a judgment. I think this again boils down to the question of where you have evidence, perhaps referred to in literature, which in the opinion of some expert is applicable to Lake Michigan -- some experts might not think it applicable to Lake Michigan -- that on the basis of that 1)whether we permit something to go on in the lake and don't prevent it and wait for damage to occur before we do anything, or 2)whether we have sufficient evidence or a sufficient cause to make a judgment that we are going to place certain restrictions on activities in anticipation that if we don't, damage might occur. I think this is the judgment we have to make after we hear all this information.

Are there any other comments or questions? Is there anyone in the audience who wants to ask a question?

MR. BANE: Charles Bane, representing Commonwealth Edison Company.

Did you hear Dr. Raney's testimony yesterday about the circumstance -- I think it was on the Pacific Coast -- in which there was evidence in fishes -- I think it was the specie of salmon -- was able to pass through without harm and to stay alive, pass through the condensing water as it went over the turbines and was discharged? Did you hear that testimony?

DR. COLBY: Yes, I heard that, right.

MR. BANE: Do you agree that it is possible that --

DR. COLBY: What size fish was that?

MR. BANE: What size?

DR. COLBY: Yes.

MR. BANE: I don't recall.

DR. COLBY: I think that would be important. I don't think it was fry. He didn't specify what size it was.

MR. BANE: Well, is it your testimony, with respect to harm to fish, it was confined to fry fish?

DR. COLBY: Yes.

MR. BANE: You wouldn't deny, then, I take it, that a fish of another size are capable of surviving, of being passed over the condensers?

DR. COLBY: No, not if he said it.

MR. BANE: Have you made any studies to determine whether fish, whether they are of the fry size or otherwise, could survive being passed through the condensing water not only over the turbines, but in a cooling tower operation?

DR. COLBY: No.

MR. BANE: Would you expect that fish could survive a cooling tower operation?

DR. COLBY: Just as intuition, no.

MR. BANE: Your intuition is that they would not survive?

DR. COLBY: Yes.

MR. BANE: Yes. Thank you.

MR. KEANE: Steven Keane from Wisconsin Public Service Corporation. And I don't think I will be able to find the answer to this one in the book.

As I understood your statement before, you were taking some issue with what I understood at least Dr. Ayers to have stated, that there were some differences in field surveys and what happened in laboratories, and I think the impression you are attempting to give us now, I take it, is that what he develops in the laboratory is sustained when you get out in the field. Am I understanding you correctly?

DR. COLBY: Yes, this one study, I feel -- it will be published in a scientific journal and the community can decide this for themselves.

MR. KEANE: But this is one study, and how confining is it? What is it a study about?

DR. COLBY: It is a study about lake herring and the effect of temperature on rate of development.

MR. KEANE: I see. Now, as I understood when

Dr. Ayers was talking, he was using as a demonstration the fact that in a body such as Lake Michigan there is a great variety of temperatures at any given time, that there are currents, that there are winds blowing.

DR. COLBY: Right.

MR. KEANE: And that a fish will go into a temperature that he wants, and this sort of thing. You agree with him, do you not, that insofar as those are applicable -- and I think they were applicable to Dr. Ayers' statements -- that there may well be differences or distinctions between what you find in the laboratory and what you find in the field?

DR. COLBY: It depends on the study. I don't know what he found in the laboratory -- what specifically he found in the laboratory that didn't agree with the field.

MR. KEANE: Well, I cannot possibly repeat his statement. Of course, you have this in writing, I am sure, but be that as it may, have you ever made any survey or study to find out whether there were differences in the field from what you found in the laboratory?

DR. COLBY: On this study on the fry, where I went out to the field and actually observed lake herring on the spawning beds and the rate of development, he predicted when the 20 phases of development would occur, and they came within 2 percent.

MR. KEANE: Are you able to duplicate current, for example, in your laboratory studies?

DR. COLBY: Duplicate current?

MR. KEANE: Yes.

DR. COLBY: I think we could.

MR. KEANE: Do you?

DR. COLBY: No.

MR. KEANE: Have you?

DR. COLBY: No.

MR. KEANE: Are you able to duplicate differences in temperature in the same bed or in the same relative area or in the same area in a near vicinity?

DR. COLBY: In other words, can we set up a temperature gradient, do you mean?

MR. KEANE: Yes.

DR. COLBY: And vertical? We could.

MR. KEANE: Do you?

DR. COLBY: We haven't.

MR. KEANE: You haven't?

DR. COLBY: No, I haven't.

MR. KEANE: Have you set up temperature gradient studies?

DR. COLBY: No, we haven't.

MR. KEANE: Well, then, don't you think from the very factor of the absence of those gradients, as you used the term, and which I presume is the correct one, that your model, as you determine it in the laboratory, is different from what would be experienced in the field?

DR. COLBY: Oh, we work at constant temperatures in the laboratory, right. You don't get this in the field.

MR. KEANE: So that there is this difference between lab studies and field studies?

DR. COLBY: But it is how you use these constant temperatures that is important. This is why we went to the field.

MR. KEANE: As I understand, you only went on this conference to satisfy yourself in this very narrow area for this hearing.

DR. COLBY: To satisfy myself that the constant temperature, that rates of development differ from the constant temperatures, and then you take these rates and apply them to the temperature regimes in the field, and, for instance, you take the time of exposure of a temperature and multiply that time by the rate and you get a progress to development. You do this for twenty stages, and as you progress -- when you get to a 100 percent progress, this developmental stage will occur. Then go back and we have put this into a computer -- all these rates -- and then when the computer looks back and goes back and starts answering to developmental stage 2, 3, up to 20. Then, we have gone to the field and we have taken temperature regimes and applied these laboratory determined rates to the field, and we get verification that they occur in a natural temperature regime. We can predict when the eggs will hatch in the lake that we are studying.

Now, with these rates, we have gone to computer simulation, and we have added 1 and 2 degrees centigrade above ambient -- 2 degrees centigrade, (3.6 degrees Fahrenheit) -- and these results from these rates predict that these eggs will hatch 29 days early.

MR. KEANE: I had no idea I was going to get that much answer for that question.

DR. COLBY: That is what happens when you ask an expert a question.

MR. KEANE: Well, I didn't understand it was cross examination. As I explained to you, sir, we are trying to get some more facts.

Now, this witness -- I call him a witness, being a lawyer, but he is, I think up here today, and he has been quite critical of the statement that Dr. Ayers, as I understood was the one that made it, that there were substantial differences between studying the life history of these fishes and other organisms in the natural bodies of water such as Lake Michigan and in the laboratory and, as I understood this gentleman was taking issue, I was simply trying to find out whether or not that was true.

DR. COLBY: There are also many studies that are in good agreement, laboratory and field. I have one in my briefcase if you want to look at it.

MR. KEANE: I am certain that Dr. Ayers' statement was not that they are exclusively all wrong, but you do not yet agree with him, then, to some extent, let us say, that studies in laboratories do not necessarily have to fall in line with what actually happens in open waters. Is that correct?

DR. COLBY: Oh, this is a case of how good the investigator is. If he sets up a poor experimental design he cannot help that his lab studies don't agree with the field or meet his predictions. Yes, that is true. It depends on the individual.

MR. KEANE: Are you satisfied that all of your laboratory studies simulate the field in their exactitude?

DR. COLBY: Yes.

MR. KEANE: You are satisfied?

DR. COLBY: I am satisfied.

MR. KEANE: Even though you do not have temperature gradients and you do not show current differentials or the effect of wind?

DR. COLBY: Yes. I think temperature is the most important and these other factors are minimal.

MR. KEANE: But you don't have the temperature gradient either because you just said that you didn't. Or did I misunderstand you? I understood you to say you do not simulate temperature gradients in the lab.

DR. COLBY: No, that is right.

MR. KEANE: That is all.

DR. COLBY: Right.

MR. STEIN: But let me ask you, Dr. Colby: Do you consider not simulating these temperature gradients in the laboratory to invalidate the laboratory correlation with your field testing when you check them out?

DR. COLBY: I think this should be done.

MR. STEIN: When you verify your work in the field, do you feel the absence of temperature gradients maintained in the laboratory do not permit you to verify with the system that you use of getting the material and running it through the computer to check it out?

DR. COLBY: No, I don't think I have to have the gradients in nature in the laboratory.

MR. STEIN: Right. Thank you.

MR. PURDY: On this matter of the eggs on the spawning bed, in the one case you are studying a constant temperature in the laboratory, and are the eggs subject to a constant temperature in the lake --

DR. COLBY: No.

MR. PURDY: -- over their spawning period?

DR. COLBY: No.

MR. PURDY: What sort of variation of temperature might they go through?

DR. COLBY: They go from lake herring spawning, 4, dropping to 3, down to .05 degrees centigrade, and up about 14 in the spring. They experience a curve like this (indicating).

MR. PURDY: So your study that you are talking about of where they would hatch that much earlier would be if they were exposed throughout this spawning period to the full 2 degrees or --

DR. COLBY: Above that curve.

DR. PURDY: Above that curve?

DR. COLBY: Right.

MR. PURDY: So if they were not exposed to that during that full spawning period, they would not hatch that much earlier?

DR. COLBY: That is right.

MR. LEHNER: Kenneth Lehner, Wisconsin Electric Power.

You mentioned that the eggs hatched 29 days prematurely.

DR. COLBY: That is right. That is right, early.

MR. STEIN: May I make a suggestion because you have possibly experienced this before, that you wait until the question is completely finished before you begin talking. Now, this works both ways. You notice the lawyers will not interrupt you usually when you have an answer, and try not to interrupt them, because otherwise we cannot maintain the record.

DR. COLBY: Thank you. I am sorry.

MR. LEHNER: You mentioned a 29-day prematurity. Could you tell me approximately how many eggs were involved? Did they all hatch exactly 29 days prematurely and, if not, what would be the statistical variation of the time of hatch?

DR. COLBY: Early hatch was determined by computer simulations. We can give you an idea of constant temperatures -- the time to hatch from fertilization. Some hatch were based on constant temperature results. For instance, an increase of temperature from 68 degrees centigrade, by 2 degrees, in the laboratory at constant temperatures would shorten the incubation period by 30 days, and we have done this.

MR. LEHNER: For every egg would it shorten the temperature?

DR. COLBY: Yes, it would do this for every egg, however, the time interval is to 50 percent hatch. We have the number, I believe it was around 140, 200 eggs -- I can't remember exactly right now -- and these would incubate and hatch -- 50 percent of them would hatch within these time intervals. So this is the time from fertilization to 50 percent hatch, and it forms a normal distribution.

MR. LEHNER: In other words, the great majority hatched at 29 days, but there were some that probably hatched at 21, and some, say, at 40.

DR. COLBY: Right.

MR. LEHNER: What I am getting at is perhaps -- would you agree that there might be some evolutionary pressures put on the indigenous fish population? Supposing that we did raise the temperature, would the species evolve to accommodate their gestation time to the new temperature?

DR. COLBY: Not in as short a period of time as we are talking about.

MR. LEHNER: To the year 2000, is that what you mean?

DR. COLBY: Thirty-five years?

MR. LEHNER: Yes.

DR. COLBY: No, I don't believe so, but I am not an evolutionist. That is my opinion. If there is an expert in evolution and he can tell me the rate of evolution and whether he actually thinks this can happen, I will yield to his testimony.

MR. LEHNER: Thank you.

MR. STEIN: Are you suggesting we put out heated water to create a brave new world?

MR. LEHNER: No, I think what I am suggesting is the relatively rapid adaptation of natural organisms to environmental changes.

MR. STEIN: Right.

MR. PETERSEN: O. K. Petersen.

I think -- this is 1970, isn't it? Just 30 years to the year 2000.

DR. COLBY: Right, oh, pardon me. Okay.

MR. PETERSEN: I trust that the rest of your mathematics are done on the computer.

DR. COLBY: Thank you.

MR. PETERSEN: I had once again a little difficulty, but I noticed that you said that if the eggs were exposed to 3.6 degrees centigrade, which I think is about 6.5 degrees Fahrenheit --

DR. COLBY: 3.6 degrees Fahrenheit would be 2 degrees centigrade.

MR. PETERSEN: I understood you to say centigrade.

DR. COLBY: Maybe I made a mistake, but I am correcting it if that is what I said.

MR. PETERSEN: Then, at 3.6 degrees, which particular fish populations -- I believe you spoke of whitefish several times -- were there some other ones?

DR. COLBY: No, this was lake herring.

MR. PETERSEN: I wasn't speaking about your study, I was speaking about your application to Lake Michigan. I think you mentioned a fear of damage to whitefish population. I wondered if there were any other fish populations which you had particularly in mind when you were making your conclusions as far as Lake Michigan was concerned.

DR. COLBY: No, those two species.

MR. PETERSEN: Whitefish and lake herring?

DR. COLBY: Whitefish is a closely related species.

MR. PETERSEN: I see. And where do whitefish spawn normally? I don't know the answer to this question, which is a little bad for a lawyer, but I find I am in a bad spot.

DR. COLBY: From all of the studies that I have read, they spawn in the shallow waters from inches out to 20 feet.

MR. PFTERSEN: In Lake Michigan?

DR. COLBY: These are in the other Great Lakes, and there is at present a study being documented by the University of Wisconsin. They haven't found the spawning area yet, but there is all reason to believe that if they do in all of the other lakes they should in Lake Michigan, too.

MR. PETERSEN: Do you have any reason to believe that the whitefish or lake herring spawning area is in the area of any present thermal plume from an electric generating station or proposed one?

DR. COLBY: We don't know where these spawning areas are. We do need an inshore ecology study to find these spawning areas, so I cannot say.

MR. PETERSEN: I have mentioned to the previous witness something about the testimony that the area for some distance out to 20 or 30 feet of depth is a relatively barren area, a relative desert, that there the benthic organisms are gone, there aren't any algae or other materials present. Do we have any reason to believe that in this particular area, subject to this wave action, that we would find the whitefish?

DR. COLBY: Yes, these are -- from the studies in South Bay mouth, they like these rocky barren exposed areas.

MR. PETERSEN: These are not rocky, these are shifting, grinding sand.

DR. COLBY: Studies in Europe show that they also lay their eggs on coarse sand. Now, the question is: The people in lands and forests believe that eggs that are laid on these bottoms do drift and roll down the beach. But we just don't know that much about whitefish eggs exposed to these areas -- on sand areas.

MR. PETERSEN: Then, really as far as you are concerned, you have no study which you have performed, and you know of no study performed in Lake Michigan or even in shifting sand similar to that on the eastern shore of Lake Michigan, pertaining to either whitefish or, as I understand it from you, the related species of the lake herring?

DR. COLBY: No, not the spawning grounds. The nursery grounds are being studied where the fry are located.

MR. PETERSEN: Now, do you have any indication that there is a nursery grounds in the vicinity of any of the present or proposed thermal discharges from electric power generating stations?

DR. COLBY: May I use the map?

MR. PETERSEN: You certainly may.

MR. STEIN: Go ahead.

DR. COLBY: The studies by Walter Hogman at the University of Wisconsin are in this area (indicating).

MR. STEIN: That is not going to show in the record.

DR. COLBY: Well, they are all along the inshore areas -- he has found 90 percent of them within 10 feet in the basin and along the shores of North Green Bay. Now, do you have a plant in there proposed?

MR. PETERSEN: I represent Consumers Power Company.

DR. COLBY: Oh, pardon me.

MR. STEIN: Well, I believe someone was in here talking about something between Fox River and Green Bay. I think the record is clear on that.

DR. COLBY: I would say that was in the area.

MR. PETERSEN: All right. You have indicated, as I understand it, an area along Green Bay from approximately the city of Green Bay to approximately the city of Menominee, and you indicated, as I noticed your finger pointing, the southeast shoreline of that bay. Now --

DR. COLBY: Southeast, and also on the Michigan shoreline of Green Bay, they found them there.

MR. PETERSEN: Michigan shoreline of Green Bay?

DR. COLBY: I mean the outer shoreline.

MR. PETERSEN: Thank you. I was having a little difficulty with that.

DR. COLBY: The west coast of Lake Michigan.

MR. PETERSEN: Now, in these areas, are any of these nurseries exposed to a thermal plume?

DR. COLBY: I don't know.

MR. PETERSEN: I see. And you, I noted, did not discuss the eastern shore of Lake Michigan itself. I take it that you haven't identified -- nor has anyone else -- the spawning ground in that area.

DR. COLBY: No, we are in a great need for an inshore ecology study.

MR. PETERSEN: Once you have the fry, have you any reason to believe that they would be harmed by being at the edge of a thermal plume where the temperature difference is, let us say, 1 or 2 degrees above ambient temperatures?

DR. COLBY: Not from temperature. If they are going into supersaturated solution and they get -- if they get into a supersaturated gas solution and they get gas bubbles in the gastrointestinal tract, I believe this would kill them, and I think it should be investigated.

MR. PETERSEN: Have you any reason to believe that the oxygen supersaturation which is described as coming just out of the condensers would continue to exist at the edges of the plume?

DR. COLBY: I don't know.

MR. PETERSEN: Is there any belief on your part that the fish would swim into the plume to a point where they became uncomfortable?

DR. COLBY: I believe this could be a possibility.

MR. PETERSEN: A possibility?

DR. COLBY: Yes, but I don't know.

MR. PETERSEN: But not a probability, or do you have any reason --

DR. COLBY: I have no reason to say one way or the other.

MR. PETERSEN: I see.

DR. COLBY: I think it should be studied. I was hoping that this was some of the evidence that we would get today.

MR. PETERSEN: I also would assume that your idea of where the lake would be heated was based on someone else's study of the inshore area and thermal bar or barrier, et cetera? I take it that the inshore area idea or -- let me start again.

Do you agree with this inshore theory that has been promulgated in this "white paper?"

DR. COLBY: Yes.

MR. PETERSEN: Now, is this theory based upon your work or someone else's?

DR. COLBY: Someone else's.

MR. PETERSEN: And you did not take part in the studies which produced that theory?

DR. COLBY: No.

MR. PETERSEN: Now, let us assume that for a small area -- let us say for the full area of the plume, we will say, take a square mile, which seems to be vastly more than would be involved in each of the plants involved -- and we add, say, 30 square miles of the lake shore covered by plume, and for this purpose, down to the bottom, which doesn't appear in the testimony, what would be the overall effect on fish population of being deprived of that amount of breeding area, if it would be such a deprivation by being raised, as we decided now, 3.6 degrees Fahrenheit?

DR. COLBY: It is my opinion that those fish that use those areas for spawning would be deprived of these areas and you would lose these fish in this area.

MR. PETERSEN: You missed the question. What would be the overall effect on the fish population of that species in Lake Michigan?

DR. COLBY: I don't know.

MR. PETERSEN: I have no more questions at this time.

MR. STEIN: Thank you.

Are there any further questions for Dr. Colby? Thank you very much, Dr. Colby. We certainly appreciate it.

Mr. Barber.

MR. BARBER: I would like to introduce now another of our fishery biologists, Mr. Thomas Edsall, from the Great Lakes Laboratory, who will make a statement.

MR. STEIN: And who comes after him?

MR. BARBER: Mr. Roberts will just read a brief statement into the record, then Mr. Callaway -- excuse me -- this other gentleman, Dr. Charlie Powers, and Mr. Callaway, and then myself.

MR. STEIN: All right. Thank you. Just so we have an idea.

STATEMENT OF THOMAS A. EDSALL, BIOLOGIST, FISH AND WILDLIFE SERVICE, GREAT LAKES FISHERIES LABORATORY ANN ARBOR, MICHIGAN

MR. EDSALL: Mr. Chairman, conferees, ladies and gentlemen. My name is Thomas Edsall. I am a research

T. A. Edsall

biologist with the Fish and Wildlife Service, Great Lakes Fisheries Laboratory, Ann Arbor, Michigan. I am one of the authors of Section IV of the Department of Interior "white paper" dealing with the "Physical and Ecological Effect of Waste Heat Discharge on Lake Michigan."

I have a Bachelor of Science degree in fisheries from the University of Connecticut, and a Master of Science degree in fisheries from the University of Michigan. My graduate studies and post-graduate studies at the University of Michigan have dealt with the physiological ecology of fishes. I have been employed by the U. S. Fish and Wildlife Service at Ann Arbor for approximately 14 years of which a total of about 6 years was spent in field ecological research on the Great Lakes. Three of these 6 years were spent on Lake Michigan. The remainder of my term of employment has been spent conducting lab studies on the environmental requirements of Great Lakes fishes including studies of the thermal requirements of these fishes.

I have recently published a couple of papers on the temperature tolerance of Great Lakes fishes. These are listed in the "white paper," and I have a ~~third~~ paper which will appear in print this fall.

I have conducted or supervised a number of other lab studies of the temperature requirements of Great Lakes fishes. These studies are now continuing or have been completed and are in the process of being drafted into manuscripts for report form.

I would like, at this time, to make two statements concerning the Department of Interior Fish and Wildlife "white paper." Firstly, there can be little doubt, even among those of you who are of a different persuasion than perhaps I am, that Section IV of the "white" paper" is as fully as possible a documented current and complete presentation of the facts describing the potential effects on the ecology of Lake Michigan of using Lake Michigan waters for cooling purposes. The lack of any serious or effective attempts to refute statements concerning fishes in Section IV of this document, I think, attests to its validity.

Secondly, I would like to speak to the problem of entrainment, induced mortality among Lake Michigan aquatic organisms.

Dr. Raney, in his discussion, related to the first filling of the swim bladder of whitefish larvae. Incidentally, I believe this was a study done by Dr. Tate of the University of Toronto, who stated -- and I think this is almost a direct quote -- whitefish larvae that rise to the surface in the hottest area of the plume would not survive.

Because the hottest area of the plume is at least as hot as the temperature of entrained water at or immediately downstream from the condensers, we must also expect that all of the whitefish larvae passing through a once-through cooling system would also be killed. Furthermore, since information on the physiology and ecology of whitefishes, including the Great Lakes whitefish and the lake herring, show them to be similar in their tolerances and requirements, we can also expect that the lake herring would also be similarly affected when passing through cooling systems or encountering the hottest portions of thermal pollution.

Other species of fishes and aquatic organisms may be similarly affected. Evidence for the loss of entrained phytoplankton has been given by Morgan and Stross, and this is a paper cited in the "white paper," and this morning by Dr. Ayers at this hearing.

As stated in the whitefish paper -- (laughter) -- I mean the "white paper" -- it is beginning to sound that way, I am afraid -- as stated in the "white paper," whitefish and herring hatch in April through May and spend about 90 days in the beach zone waters as larvae. The thermal bar is present at this time or at least during the months of April and May and retards mixing of the beach zone water with the waters farther offshore. Any installation drawing cooling water from the beach zone will draw in larval fishes and plankton in the beach zone waters especially during the time that the thermal bar exists, and according to projections in the "white paper," by the year 2000, the water drawn into these plants daily will amount to about 1 percent of all the water in the beach zone area of Lake Michigan proper. In the Chicago area this amounts to about 4 percent daily of the beach zone water. These are projections. Nearly all of the water in the Lake Michigan beach zone area should pass through cooling intakes once during the period of beach zone residence of larval whitefishes. The whitefish here means herring and lake whitefish. That is, 100 days or during the period April through June. In the Chicago -- that is a parenthetical statement -- in the Chicago area, only 25 days would be required to pass all of the beach zone water in that area through cooling systems.

According to sources cited above, Morgan and Stross, Ayers, and Dr. Raney, all or nearly all of the organisms in this intake water would be, in fact, killed. Complete destruction of the class of herring or whitefish could be accomplished during the first few months following hatching.

T. A. Edsall

Of course, it is probably not reasonable to assume that all beach zone waters will pass through the cooling system only once and, therefore, that all of the Lake Michigan beach zone waters will be passed through cooling systems in 100 days, and that this same thing would be accomplished in the Chicago area in 25 days. Longer times would undoubtedly be required for these areas to be drawn through the plants. If, however, we add to the mortality caused by passers through the plant, the mortality that would be caused due to entrainment in the discharge waters, I think, we are going to find that the two types of mortality are going to tend to complement each other.

Whitefishes that are entrained in discharge waters and exposed to the hottest water in the plume -- I seem to have lost my place here.

Basically what I am trying to say is that the Pritchard model, which was Model No. IV, I believe, or No. III, which has a high discharge velocity, would cause a high degree of entrainment of lake water at the discharge point, and that this would also tend to draw in fairly large numbers of fish larvae that were present in that area.

There is little doubt in my mind that if this man-induced mortality is added to the mortality from natural causes, which are already acting to limit the abundance of whitefishes, that the collapse of populations of whitefishes in the Great Lakes could certainly be expected by the year 2000 if not before.

Furthermore, any other fish species similarly vulnerable to entrainment would also be expected to suffer a similar fate.

That is all I have.

MR. STEIN: Let's just wait to see if the panel --

MR. PURDY: Doctor, in equating the problem, do you equate the problem of drawing organisms through the condenser has to be greater than the heat plume?

MR. EDSALL: I am sorry, I really don't think I can answer that. I would say that on the basis of the available evidence, that all organisms drawn through the condensers -- the organisms that I specified -- would be killed. Organisms drawn in by entrainment, according to Dr. Raney, if they get to the hottest portion of the plume, would also be killed. I don't know what volume of water would actually be entrained for a given discharge volume of water and I would have to know this before I could answer your question.

MR. PURDY: Well, there are many schemes that can be utilized to meet the problem and -- for example, if the heat discharge is exceptionally significant, then the so-called closed system with very little blowdown possibly has to be looked at. If the heat problem is not so great, but it is the matter now of physically dragging all of these organisms through the condensers, possibly you can look at a cooling tower that has a significant blowdown now to control corrosion products and the buildup with solids in it. I am attempting now to sort out what various schemes of controls could possibly be used to meet the conditions that you are now describing.

MR. EDSALL: Well, as I said, I feel that any organism that is drawn into the condenser tubes and experiences a 20-degree Delta T, I guess that it is typical. According to the expert witnesses that the power companies have presented, the organism would die. Similar effects would be expected in the discharge effluent.

I expect that anything that passes through cooling towers would also be killed. Am I answering your question?

MR. PURDY: Yes. I realize that, but I don't want to misconstrue your answer to me. You apparently feel that some heat could be put into the lake if we can control this other problem.

MR. EDSALL: I don't want you to misquote me. I certainly didn't say that.

MR. PURDY: Am I wrong in this assumption, then?

MR. EDSALL: Your assumption is that some heat could be put into the lake if we could control the problem of mortality of entrained organisms?

MR. PURDY: That is correct.

MR. EDSALL: You would solve the problem related to the entrained organisms if you kept heat out of the lake, I suspect. The heat would have other effects which have been described by Mr. Carr, and Dr. Colby, and will be treated in more detail by Dr. Powers and others.

MR. PURDY: Okay.

MR. STEIN: Are there any other comments from the panel?

Let me ask you, if I really understood what you said. If we pursue the kind of pass-through devices for all of the plants we heard about today on Lake Michigan -- and let's assume that we have the same kind of system throughout the Great Lakes -- and we set up relatively uniform requirements -- then if we do that, we are going to wipe out the whitefish in the lakes by 2000?

MR. EDSALL: I say that might be a good guess.

MR. PURDY: I think this is fairly important, Mr. Stein, because we are not talking now about a thermal standard, we are talking about actually extracting them out of the lake.

MR. STEIN: I understand that. That is why, again, I made that little talk before. We are talking in terms of closed systems, because if this is what we are up against -- and I find this more and more in various aspects of the problem as we go around the country -- I certainly think the conferees and the industry have to be thinking in terms if this is, in fact, the issue. I am making no judgment on the validity of the statements and all that, but I read the implications, Mr. Purdy, just as you do. I have heard this pretty frequently today.

MR. PURDY: It seems to me that this is a separate subject and should not be dealt with jointly with the thermal standards.

MR. STEIN: Well, that may be true, but the question here is perhaps when we started dealing with this several months ago you thought you could separate the thermal standard out. Now, I may be wrong, but as I understand it, and I am not talking about feasibility or economics or practicality -- but if you have a closed system where they carefully screen and design intake and a blowdown and you are careful what you do with the waters you are disposing of, you can handle, at least on a theoretical basis, both the intake problem and the entrainment problem, the bruising problem, the mauling problem, the adding of the chlorine, the discharge of the waste, the hydraulic problem. It can all be handled theoretically, at any rate, with a closed system, as well as the heat rise. I think we have to recognize -- and I think we heard the suggestion from Dr. Ayers -- maybe if we are thinking in these terms, we have to give it careful consideration to at least meet part of the problem with interim requirements, until we can really get to the dimensions of it.

Now, I don't know. As I say, the implications of this seem to me to raise the same questions that you raised in your question, Mr. Purdy. I think we are just going to have to move toward meeting them.

Are there any other comments from the conferees? If not, may we hear from the audience.

MR. EDSALL: I wanted to answer Mr. Purdy to say that the subject of this entrainment damage was introduced on Pages 74 and 75 of the "white paper" under the heading Intake Damage.

MR. STEIN: I think he said that he did include a reference to this in his report.

Go ahead.

MR. FELDMAN: My name is Daniel Feldman. I am from the firm of Isham, Lincoln and Beale, and I am here on behalf of the Commonwealth Edison Company. Mr. Stein, if I may ask one preliminary question. I have some questions which relate to the statement of clarification which Mr. Barber read on Monday, and I don't know who it is appropriate to ask about this.

MR. STEIN: Well, I'll tell you, Mr. Barber is here, and why doesn't he come up? If Mr. Edsall cannot answer the question, Mr. Barber will respond. In the interest of time, if this is all right with you, you propound your questions, and we will try to find the man to answer them.

MR. FELDMAN: Well, I do have some questions also which go directly to what this gentleman has just said. I might start with those and then go to Mr. Barber.

MR. STEIN: In other words, you handle the questions the way you wish.

MR. FELDMAN: Okay.

Lastly, Mr. Stein, do you mind if I sit down while I ask the questions?

MR. STEIN: Perfectly all right. Go ahead.

MR. FELDMAN: To be sure that I understand what you were saying about the whitefish larvae, might I restate what I thought I heard you say? You began by quoting Dr. Raney's statement with respect to whitefish larvae which go through the condenser or which are in the hottest part of the plume, and then as your exposition went on, you discussed those whitefish larvae which may be entrained in the plume assuming a high velocity discharge. Is that a fair resume of what you said?

MR. EDSALL: I think what I said was that in discussing the process whereby whitefish larvae first fill their swim bladder, they are required to rise to the surface and gulp air. This is what Dr. Raney was talking about. He said, then, that those that rose to the surface and encountered the hottest part of the plume surely would die.

Now, if they encountered the hottest part of the plume, certainly the temperatures upstream toward the condensers would be higher; consequently anything coming through the plant would experience higher temperatures and in the plume would certainly be killed. Also organisms that were entrained by the plume and did, in fact, reach the hottest part of the plume would also be killed.

MR. FELDMAN: Organisms, in this case, means whitefish larvae, and when you say that, are you saying that an organism if entrained by the momentum of the plume that it may be carried to the point of discharge from the place at which it was entrained?

MR. EDSALL: I visualize entrainment -- and I am not a biological engineer or anything of this sort -- but it would be a current moving very quickly in one direction with a fairly sharp, sheer surface. But at the surface, at the interface between the plume and the surrounding water, some of the surrounding water would be, because of the motion of the plume, drawn to the plume. Does this ring any bells?

MR. FELDMAN: Let me put it the other way. Assume a pipe is discharging into the lake. The pipe leads from the powerplant to the lake. The velocity of the water coming out of the pipe is approximately 7 feet per second. Assume the Zion plant on the west side of the lake, and the pipe is pointed toward the east side of the lake. With water coming out of that pipe at 7 feet per second, wouldn't you assume that the movement of water is away from the pipe toward the eastern shore, and wouldn't your assumption that organisms which are entrained will move back toward the end of the pipe -- isn't that assumption clearly erroneous?

MR. EDSALL: I am speaking of Pritchard's Models III and IV in which velocities were -- can someone help me -- were 3 and 10 -- much higher, and it is my impression that organisms that would encounter the edge of this plume would be actually going into it.

MR. FELDMAN: Are you suggesting to me that in Dr. Pritchard's Model IV -- Case IV -- an organism entrained in the plume would tend to move in the direction of the discharge pipe rather than out toward open water?

MR. EDSALL: No. With the direction of the flow towards open water.

MR. FELDMAN: And in Case IV, doesn't the temperature of the water decrease as it moves away from the discharge pipe?

MR. EDSALL: That is correct.

MR. FELDMAN: So that an organism which was entrained would be subject always to temperatures lower than the temperature at which it entered the plume?

MR. EDSALL: That is correct.

MR. FELDMAN: And it would never reach the hottest part of the plume, would it?

MR. EDSALL: Organisms entrained -- let's say at the point of discharge -- would be, then, at the hottest part of the plume, is that correct?

MR. FELDMAN: But an organism entrained at any point after the hottest part of the discharge would never be exposed to the hottest part of the discharge, would it?

MR. EDSALL: That is correct, as I see it.

MR. FELDMAN: Do you recall the size of that part of Dr. Pritchard's Case IV which is in excess of 14 degrees above ambient?

MR. EDSALL: No, sir, I do not.

MR. FELDMAN: Would it refresh your recollection if I suggested that it was 100 feet?

MR. EDSALL: If that is what it says, I will accept that.

MR. FELDMAN: When you made the statement that organisms entrained in the plume might be killed, what were you assuming in the way of transit time within the heated water, and what were you assuming in the way of degrees above ambient temperature?

MR. EDSALL: I based that statement on Dr. Raney's statement in which no times were given.

MR. FELDMAN: And if Dr. Raney's statement was that 20 degrees above ambient might be fatal to fish, then would you agree with me that a whitefish larva exposed at any point after the plume reaches 14 degrees would not suffer mortality?

MR. EDSALL: No, sir, I wouldn't.

MR. FELDMAN: Does it seem to you that a whitefish larva exposed to 14 degrees for 29 seconds would suffer mortality?

MR. EDSALL: It depends on the type of mortality that you are talking about.

MR. FELDMAN: I didn't know that there was more than one. Could you explain that to me?

MR. EDSALL: Yes, sir.

There is another theory that says that exposure of organisms -- in this case I am talking about fishes -- to temperatures that are considerably below the temperatures that will be immediately lethal to them will be reduced in their ability to avoid predators. Okay?

MR. FELDMAN: And does that statement apply to whitefish larvae?

MR. EDSALL: I think it would apply to salmonids. The study was originally done by Dr. Charles Coutant of Battelle Northwest Laboratory, in which he showed that young rainbow trout and chinook salmon exposed to temperatures that were approximately 25 percent -- let me state this correctly -- to heat doses that were only

25 percent as large as those required to cause the organism to lose equilibrium, would be statistically more susceptible to predation by predators. The heat dose that is required to cause the loss of equilibrium is approximately 90 percent of that that is required to cause direct mortality. The whitefish is a salmonid.

MR. FELDMAN: Excuse my confusion. I thought we were discussing whitefish larvae, and I would not have expected that a larva had the kind of agility which a fish uses to escape predators. Is that wrong?

MR. EDSALL: I am sorry. Would you repeat that?

MR. FELDMAN: I would not have thought that the larva stage of a fish had the ability to escape those fish which are predators on it, does it?

MR. EDSALL: That is a good question. I think I would have to answer yes.

MR. FELDMAN: And at what temperature level above ambient do you believe whitefish larvae are subject to the kind of impact which may impair their ability to escape predators?

MR. EDSALL: Twenty-five percent of 90 percent of whatever temperature Dr. Raney was talking about.

MR. FELDMAN: Okay, then, ultimately your statements about whitefish larvae depend upon what Dr.

Raney would say is the mortality or stunning figure for them.

MR. EDSALL: Any comment I would have to make right now certainly would depend upon his statement.

MR. FELDMAN: Okay.

In your discussion, you also assume, I think, that 4.4 percent of the beach zone water would be going through the condensers in the year 2000.

MR. EDSALL: That is correct.

MR. FELDMAN: Am I correct in assuming that that statement of yours depends on the assumption that there was no mixing across the thermal bar?

MR. EDSALL: I would think that the existence of a thermal bar certainly would enhace the possibility of this occurring.

MR. FELDMAN: No, what I am really asking is: Didn't your percentage, 4.4 percent, depend on once assuming that the beach zone is a wholly separate body of water which does not mix with the rest of the lake?

MR. EDSALL: Basically I think that would be a fair assumption.

MR. FELDMAN: And if the beach zone mixes with the rest of the lake, then your 4.4 percent figure is erroneous, is it not?

MR. EDSALL: Only in the sense that the larvae remain in the beach zone area. They are moving up and down the beach with response to currents. They will, in fact, remain in this area and will be susceptible to being drawn into the intakes.

Now, if the water that they are in is water that has drifted in from offshore, I don't really see how it makes any difference.

MR. FELDMAN: Well, Mr. Edsall, you were making a statement about the percentage of water that will circulate through the condensers, and the statement was made that in the Chicago-Gary area all of the water will go through the condensers every 25 days. Is that a fair statement of what you said?

MR. EDSALL: That is correct.

MR. FELDMAN: Mr. Edsall, if the amount of mixing between the beach zone and the rest of the lake is a figure which is in excess of the amount of water being taken through the powerplant condensers -- do you have any assumption?

MR. EDSALL: Any water coming into the beach zone from farther out in the lake is in excess of water being taken into the condensers, is that what you said, sir?

MR. FELDMAN: Nope. Do you regard that your statement that all of the water in the beach zone will go through the condensers every 25 days as an accurate statement?

MR. EDSALL: As I said a minute ago, it doesn't really, in my estimation, make any difference whether or not there is water moving in and out of the beach zone as long as the larvae remain in the beach zone and are susceptible to being drawn into the intakes. We use the beach zone simply to describe a convenient volume of water to demonstrate possible thermal effects.

MR. FELDMAN: Just for the record, the year 2000 estimate, which you were using, which yields 4.4 percent, is based, is it not, on the assumption of 30 megawatts -- excuse me -- 30,000 cubic feet per second of cooling water in the Chicago-Gary sector?

MR. EDSALL: It was based on 91,000 cubic feet a second in the entire beach zone, and I offhand don't recall what the volumes were in the Chicago-Gary, Indiana, area, but I am sure it is in the report there.

MR. FELDMAN: Mr. Edsall, let me show you Table 11 of the paper, and ask you to confirm to me, if you can, that the volume for the Chicago-Gary area in the year 2000 is 30,000 cubic feet per second.

MR. EDSALL: That is correct.

MR. FELDMAN: And that figure in turn depended on the capacity figures shown in Table 7, which show 30 megawatts of capacity in the year 2000 for that area.

MR. EDSALL: Yes, I believe it does. May I say that I had no hand in calculating these figures. We discussed some of these numbers. My input was strictly to Section IV dealing with fish and wildlife interactions.

MR. FELDMAN: That may well make my next question inappropriate, and I would only ask you to answer it by telling me who I ought to direct it to.

The question is: That year 2000 figure was based, was it not, on the Acres' report, except that the surveys took the Acres' figures and increased them by 30 percent.

MR. EDSALL: I would like to redirect that question to someone who has more expertise in the area, if I may.

MR. STEIN: Do you want to come up, Mr. Roberts? May we go off the record?

(Discussion off the record.)

MR. STEIN: Let's go back on the record.

MR. ROBERTS: Okay, I didn't exactly catch which extremes were you were referring to. However, Mr. Barber did point out why we did go to 100 percent capacity operation in our estimation and projections.

MR. FELDMAN: I am sorry. I may well have missed that part of the discussion and I wonder if you could repeat it to me.

MR. ROBERTS: Well, Mr. Barber basically said that since we are particularly interested in ecological extremes and we are most interested with the times that most of the waste heat is going into the water, and this would be at a time of 100 percent or maximum operational capacity.

MR. FELDMAN: Isn't the statement of operation at 100 percent of capacity -- a statement that the powerplants are going to talk about -- are going to operate wide open, at nameplate capacity, 24 hours a day, 365 days a year? Isn't that what 100 percent of capacity means?

MR. ROBERTS: Not to my understanding. My estimation of description of 100 percent capacity would be when the lights tend to become a little dim, which we hear quite a lot about lately.

MR. FELDMAN: Mr. Stein, it is unfortunate, I think -- if I could be a little more informal -- that

Mr. Barber is probably the most appropriate witness.

MR. STEIN: Why don't you come up, Mr. Barber?

MR. BARBER: Sure.

The figure that we used there is computed first -- first we tried to determine what the probable existing capacity would be on the lake We fully recognize that no plant is going to run 100 percent of the time all the time.

Now, the 91,000 c.f.s. is the figure, the volume of discharge, which would be occurring when and if all of the units were running at 100 percent. In other words, we were searching for these extreme conditions that we mentioned earlier. As, for example, when New York is in brownout.

MR. FELDMAN: When the plants are running wide open?

MR. BARBER: Yes, that is right.

MR. FELDMAN: When you come to discuss daily and annual input of B.t.u.'s to the lakes, and their impact upon the ecology, and in particular when you tend to talk about what will happen over a spawning season in April, is it fair to assume 100 percent capacity operation?

MR. BARBER: Let me say this: A 100 percent operation can and might be demanded of any plant in any system. Is this not fair? I mean, under emergency conditions. You have a plant that goes out, you are going to make it up elsewhere in the system, is this right? So that any plant theoretically could run at its maximum for the period of time during an emergency outage. This would be that period when you would be discharging maximum waste heat. What we were looking for is that maximum which affects the largest area most severely.

MR. FELDMAN: Mr. Barber, do I understand you to be saying that April, May, and June have in any year of record been maximum electrical load months in the Middle West?

MR. BARBER: I doubt that they have, sir.

MR. FELDMAN: And, as a matter of fact --

MR. BARBER: But they could be, if you had a plant that went out, and they do go out. I remember four or five going out in my area just last week.

MR. FELDMAN: But your paper assumes that 30 plants are operating -- that is plants in 4 states -- all around the lake. Do you regard that as a rational assumption?

MR. BARBER: With the power demand that you are going to have in the year 2000, you are going to be running it at 70 percent all of the time, according to the Acres Report.

so this is only really less than a 50 percent increase in your normal operation. I realize that 100 percent operation all of the time would not be a fair allocation of it, but I would say that your estimate of capacity might be conservative.

MR. FELDMAN: Mr. Barber, while I am here, maybe I can shift those questions to the clarifying statement you issued on Monday. Do you have a copy of that in front of you?

MR. BARBER: No, I don't, and I was going to ask Mr. Roberts if he would bring me one.

While I am here, and while we are waiting for that, I might, I think I might be able to clarify for you this question of the 4.4 percent. This was an effort on our part to illustrate the fact to anyone who read the report that we weren't just talking about some little dribbles of water. That at maximum we could be turning over a very, very significant volume of lake water and passing it through the system in that lower area there. It would not be dependent upon the existence of the thermal bar at all, and I think you have heard testimony here that the thermal bar usually begins somewhat further out than the beach water zone. We were trying to relate the volumes of water subjected to heat input in that important biological area.

MR. FELDMAN: But its ecological significance depends on your ability to consider a separate part of the lake, doesn't it? Otherwise you are simply passing through .014 percent of the whole lake, aren't you?

MR. BARBER: I think we have to consider that surface water does, as a matter of fact, exist as a little bit separate from, say, the water below the 200-foot level and things of this sort. We consider the beach water area ecologically significant. I might also point out that when you start pumping those volumes of water with those velocities, we don't have any idea yet what the power problems might be with regard to these biological matters.

MR. FELDMAN: Mr. Barber, if you can and I can be in agreement that the water --

MR. STEIN: May I say, let's try to -- please don't both talk at once. We do want to have this rigid question and answer, and obviously if you both talk at once we are not going to get it.

MR. FELDMAN: Mr. Barber, let me start all over. I was asking you really whether it was a separate body of water. I thought you referred to, sure it is different from the water which lies below the 200-foot depth line. And I was trying to agree with you, taking the 200-foot depth line is perhaps the location of the thermocline; I think we can agree. I thought we would agree that if the beach zone water and the water out in the open lake above the thermocline were one body of water, we might regard that as a distinct body for the purposes of the discussion we are having.

MR. BARBER: I don't think it is in any way reasonable to associate a heat input to a 4.4 percent beach water volume to the surface water of the mid-lake, no. I used thermocline just simply as an extreme. I don't know where the line would be drawn. I think that Mr. Carr established quite clearly that at certain times there is a thermal bar which tends to positively separate the inshore water from the offshore water for a period of about six weeks in the spring. Therefore, in that case, I don't think we would be talking about the same body of water for that period of time, even though there might be some minor interchanges.

MR. FELDMAN: Two things: This thermocline -- this thermal bar -- was not located at the same place as the boundary of your beach zone, was it?

MR. BARBER: That is correct, it was not. This would mean --

MR. FELDMAN: And the accuracy of your statement depends upon the amount of mixing which occurs across the thermal bar, does it not?

MR. BARBER: I think our statement is, sir, that it is a volume of water equal to 4.4 percent of the volume of the beach zone. It might also be 4.4 percent of the volume of New York Harbor. I don't know, you see.

MR. FELDMAN: Right. And what I am trying to get to is: Haven't you defined the beach zone in a perfectly arbitrary manner just by drawing a line on a map, and that is all?

MR. BARBER: No, sir. We think that there are cases of biological significance within this 30-foot zone. It might vary from place to place, it is true. We did have to have something though, and if we talk abou 32 feet here and 16 feet there and 100 feet beyond there on a lake the size of Lake Michigan, it becomes totally unmanageable as a subject.

MR. FELDMAN: But your ability to consider it separately in the way you just did depends upon its being separated in some way from the waters in the rest of the lake just beyond the edge of your beach zone, does it not?

MR. BARBER: I don't think so, sir, not in my estimation.

MR. FELDMAN: Do you now have a copy of your clarifying statement in front of you?

MR. BARBER: I do, sir.

MR. FELDMAN: The last paragraph of that paper, Mr. Barber, refers -- it says, "This does not alter the important conclusion of Subsection 2C ..." -- I have been unable to locate Subsection 2C. Could you tell me where it is?

MR. BARBER: Yes, sir, just one moment.

If you go over to Page 41, there is a study of model plumes, No. 2, and below that there is an "A" and on 42 there is a "B" and if you come on over, you arrive at a "C" on Page 44. This is all under Section 2. That extends over to Page 46.

MR. FELDMAN: Well, maybe the only way to get at this is, then, to go through with you Pages 44 and 46, and see what changes you have made in them.

Would you take a look at Page 46, please?

MR. BARBER: All right, sir. Let me say, at this point, that this section of the report was written by Mr. Callaway at the lab in Corvallis. We were the ones who didn't do too well in the editing which required revision and, if I may, I might refer a question to Mr. Callaway if it is necessary in order to give you a clear answer.

MR. FELDMAN: Is he here?

MR. BARBER: Yes, sir. He is right back there.

MR. FELDMAN: It might save time if he were with you.

MR. BARBER: He helped us clarify this thing.

MR. FELDMAN: Would you look with me, please, at the first sentence on Page 46.

MR. BARBER: This is the one that begins, "However ..." --

MR. FELDMAN: "However, from the earlier discussion of heat dissipation, it appears that ..." -- and so on, until it gets to the phrase: "that the assumption of little or no waste heat loss to the atmosphere is reasonable, at least during a great deal of the annual temperature cycle."

Now, do you regard that statement as still accurate?

MR. CALLAWAY: No, that is not accurate. That part isn't accurate. That is where a little bit got lost in the translation between Corvallis and Washington.

Let me go over what my intent was. My understanding, at the outset of this "white paper," was that there was a confusion between jet entrainment, turbulent diffusion, and cooling to the atmosphere, and as it was explained to me, there are two factions. One said none of the heat was lost to the atmosphere; the other said all of the heat was lost to the atmosphere immediately.

I wrote the section to explain that if a plume is going to maintain its shape as heat is entering the lake at some place, then heat has to leave at some place, and the place where it leaves in a jet is near the water, when the excess temperature approaches the ambient. And I went through, at great length, to clarify it, and didn't apparently because in the editing it got lost.

Now, I think what I have done --

MR. FELDMAN: Mr. Callaway, I don't want to interrupt, but I have a couple of more specific questions about the accuracy of the sentence, and then maybe by the time I finish them we will be in agreement with respect to what Section 2C is intended to say.

Would you look at Page 45, Table 14? The dilution table example on the left-hand side of the page, as an example of what occurs in the real world, has been retracted by you, has it not?

MR. CALLAWAY: Yes, sir. Well, again, these two -- in the initial writeup that I gave -- were to show what would happen for a substance that wouldn't decay at all, a conservative substance, and one that would decay, to put a little bit -- put the problem on a better perspective because there was a lot of confusion about the size of the area. It was nowhere indicated, and I don't think it is indicated in here that this is a real life situation, because and only because the model is, as used by Dr. Pritchard, unverified.

MR. FELDMAN: I am sorry. I didn't hear the end of that, Mr. Callaway.

MR. CALLAWAY: The model which was used to go through these manipulations by Dr. Pritchard for these calculations is not verified. That is just a term to indicate that there wasn't any real life data to go with it.

MR. FELDMAN: Are you familiar with the fact that other of Dr. Pritchard's calculations for discharge plume have been verified by measuring the temperature after the discharge?

MR. CALLAWAY: I have seen one example of that.

MR. STEIN: Was any of that verification put in the record by Dr. Pritchard, put in the record here?

MR. CALLAWAY: Just in the paper he gave yesterday.

MR. FELDMAN: When you say the one example, you are referring to the example in his paper of the Waukegan plume?

MR. CALLAWAY: Yes.

MR. FELDMAN: And are you aware of any other discharges of his that have been verified by actual experience?

MR. CALLAWAY: I am sure they have, but that is the only one I have seen.

MR. FELDMAN: Would you turn to the bottom of Page 41 and the top of Page 42? In that discussion of Mr. Benedict's plume, there is a statement on Page 42 that the study made no allowance for surface heat loss. Do you find that statement?

MR. CALLAWAY: Page 42, right?

MR. FELDMAN: Right. Would you agree with me that the error in that assumption makes the first -- the two paragraphs I referred to at the bottom of 41 and the top of 42 -- irrelevant to the discussion of what happens to the lake?

MR. CALLAWAY: I am not sure I follow you.

MR. FELDMAN: As I understand the discussion on Page 42 at the top, the Benedict study made no allowance for surface heat loss. It seems to me that you and I have agreed that there should be an allowance for surface heat loss, and therefore that both of those paragraphs -- that is the full discussion of the Benedict study -- are not useful in a discussion of what happens in the lake.

MR. CALLAWAY: The purpose of this example, again, was to give some perspective for laymen, or whatever you want to call them, for dimensions of these plumes for different situations.

MR. FELDMAN: Does the Benedict study represent a plume that you would expect to find in real life on any lake?

MR. CALLAWAY: No.

MR. FELDMAN: And so, then, on the bottom of the second paragraph on Page 42, you say that the thermal plume would extend a substantial distance and thus cover an extensive area. You really weren't talking about the real world, were you?

MR. CALLAWAY: Well, I don't believe those are my words there.

MR. FELDMAN: Well, do you regard those words as inaccurate?

MR. CALLAWAY: Inaccurate.

MR. FELDMAN: And under the clarification they should be deleted from the report?

MR. CALLAWAY: I suppose so.

MR. FELDMAN: Would you turn back to Page 46 with me? Five lines up from the paragraph which begins that page is the phrase, "...the 'dilution only' assumption of the other two examples is the more applicable."

Do you see that?

MR. CALLAWAY: Yes.

MR. FELDMAN: Do you agree with me that the effect of the clarification is to withdraw that phrase?

MR. CALLAWAY: Yes, it has lost a little bit in the translation.

MR. FELDMAN: Mr. Callaway, the clarification statement which was read on Monday says in its last paragraph that "...under some conditions large percentages of the discharged waste heat are added to the water mass of the lake." Could you tell me what those conditions are?

MR. CALLAWAY: Well, at the outfall, all of the heat is going into the lake. Eventually the plume comes to the equilibrium and there is a balance, and all of the heat has left over a certain time interval.

MR. FELDMAN: So, your reference to the word "conditions" was not a reference to where the discharge is located, or what the bottom is like, or the amount of water into which it discharges, or the velocity of the water, or anything else. It was simply a reference to the fact that for perhaps 100 feet or so all of the heat is, in fact, in the water.

MR. CALLAWAY: Well, that is true, but I think that if Mr. Barber wants to explain that paragraph that is his privilege.

MR. FELDMAN: Mr. Barber, could you tell me what you meant in that last paragraph when you said that "... under some conditions large percentages ... are added to the water mass of the lake"?

MR. BARBER: Yes, sir. This would mean that under some conditions, the bulk of the heat in the water leaving the pipe would go into the lake; it would not get away into the air in the next few minutes.

MR. FELDMAN: You mean if I put it in the bottom of the lake, it would stay in the lake until it got to the surface? That is all you are saying?

MR. BARBER: Well, I think we were saying a little more than that. You understand when we consider plumes we have to consider more than these two hypothetical models. We have to consider the real cases and, as I understand it from Dr. Pritchard's examples, there are variations on how much of the heat gets into the lake and how long it stays there. His Case II and Case III I think illustrate that on one type of discharge much more of the heat goes into the lake and stays much longer than does in his Case No. IV.

MR. FELDMAN: Maybe we can clarify this, Mr. Barber, if you would turn to Page 88. Page 88 is the page on which the Service begins its statement of conclusions, is it not?

MR. BARBER: Yes, sir.

MR. FELDMAN: And your clarification statement Monday does not refer to Page 88 or any of the conclusions, does it?

MR. BARBER: No, sir, it does not.

MR. FELDMAN: Would you read with me Conclusion No. 2?

MR. BARBER: Yes, sir.

MR. FELDMAN: "At times very large percentages (up to virtually 100 percent) of the waste heat discharged to the lake are diffused into the beach water zone;..." Could you tell me what that means, Mr. Barber?

MR. BARBER: Yes. That a very large part of that heat goes into that beach zone water.

MR. FELDMAN: Does that say anything more than that the discharge pipes are physically located in the beach zone?

MR. BARBER: As I remember from drawings we saw of a plant I don't think their pipe is out there, but some of the plume drawings that Mr. Fetterolf showed me back in June certainly suggested that there was a lot of heat in that water on the lake.

MR. FELDMAN: Excuse me, Mr. Barber, the beach zone, as I understand it, is from the shoreline from the dry land out to 30 feet.

MR. BARBER: Yes, sir.

MR. FELDMAN: Now, does the first phrase in Conclusion 2 say more than that the end of the pipe occurs someplace between dry land and the 30-foot depth?

MR. BARBER: I think it could be inferred to mean more than that, sir.

MR. FELDMAN: And what more could it be inferred to mean?

MR. BARBER: Well, that this heated plume of water (if, for example, a jet discharge) was thoroughly mixed with the receiving water, and if the heat was still below the water surface rather than going into the air, and if it was a longshore current that turned that plume down the shore, then I think it could still be within the 30-foot contour.

MR. BARBER: But that is an interesting aside. You have in all of the discussion in the "white paper" of discharge schemes assumed that the discharge was at the shoreline and that the plume would tend to hug the shore, have you not?

MR. BARBER: To a considerable extent, yes. This is because most of the powerplant designs that we have examined have involved either inshore or near shore discharges.

MR. FELDMAN: But your other paper deals with six alternative mechanisms. There is -- and we have discussed in this section -- the seventh mechanism which is putting the pipe farther out in the lake and giving this a velocity, right?

MR. BARBER: You mean Dr. Pritchard's model?

MR. FELDMAN: Right. And that model isn't discussed anyplace in the "white paper" or anything like it.

MR. BARBER: No, sir.

MR. FELDMAN: When you modify Pages 41 through 46 of the "white paper" -- that is those pages we have just been talking about -- by issuing the clarifying statement on Monday, did you, at that time, consider whether you ought to modify either Conclusion 2 or Conclusion 3 on Page 88?

MR. BARBER: Two or 3? I don't believe that I did. Did you?

MR. ROBERTS: I considered it.

MR. BARBER: Yes.

MR. STEIN: Mr. Feldman?

MR. BARBER: Mr. Roberts said he did consider it. I did not frankly, but if I had I doubt if I would have modified it significantly if at all.

MR. FELDMAN: Well, take a look at the last phrase in the third conclusion.

MR. BARBER: Yes, sir.

MR. FELDMAN: It reads, "...it is not difficult to envision resultant physical warming of a large proportion of the beach water zone and certain adjacent waters."

Doesn't that statement, Mr. Barber, depend upon the assumption in Pages 41 through 46 that the heat stays in the water, and having withdrawn that assumption don't you have to withdraw that phrase?

MR. BARBER: I don't think -- we don't on a permanent basis. We have sought to withdraw any assumption or any inference that the heat stays in the water permanently.

Now, Mr. Callaway testified here on Monday that there was something in the order of possibly a 10-day half life or heat in water. Dr. Pritchard didn't favor us with a time period, as I recall, but I have been told -- and I can't verify this -- that he used a figure of maybe 10 days offhand at the Illinois hearing. That may not be accurate, but it is the same ballpark with Mr. Callaway's figure, and so we have nowhere sought to imply total heat retention. As I said earlier, we needn't kill a fish but once.

MR. FELDMAN: I understand what you are saying about the length of time it would take a plume to die out if you turned the powerplant off.

MR. BARBER: Right.

MR. FELDMAN: But my question to you is: Since you now admit there is substantial surface cooling, do you think that it is fair to conclude as you have on Page 88 that there will be substantial physical warming of a long proportion of the beach water zone? Doesn't that conclusion, Mr. Barber, really depend on the heat staying in the lake forever or for a substantial length of time, rather than being given off at the surface?

MR. BARBER: Obviously the longer it stays there the more likely it is to affect something over a given area. But I don't see where there is any requirement for a forever circumstance there, and we never intended any.

MR. FELDMAN: Maybe I can put it this way: Is your position with respect to surface cooling that Pritchard's Case IV is in error, and that the extent of isotherms on a discharge like this is really much greater than he shows in Case IV?

MR. BARBER: I think I might refer that question to Mr. Callaway if I may.

MR. CALLAWAY: The Pritchard Case IV in the paper he gave yesterday?

MR. FELDMAN: Yes.

MR. CALLAWAY: I don't think any of Pritchard's cases that were given yesterday mean a thing unless you have the mathematical model that goes with it.

MR. FELDMAN: I am sorry, I missed your statement. You don't think that any of Pritchard's cases are --

MR. CALLAWAY: They don't mean a thing unless you have the assumptions, the boundary conditions, the mathematical model that went with it, the computer code, the whole thing. Otherwise it is just anybody's guess.

MR. FELDMAN: If we supplied you with the calculations on what Dr. Pritchard based his diagram of Case IV would you then believe that it can be done?

MR. CALLAWAY: No, because there is no such outfall to begin with. How are you going to verify it?

MR. FELDMAN: You are saying that unless we can verify in the field a mathematical model is not a useful device, and we cannot say that it could really exist?

MR. CALLAWAY: It is witchcraft. If you don't verify it, what good is it?

MR. FELDMAN: Okay. I thought you agreed with me a little earlier that Dr. Pritchard had done calculations --

MR. CALLAWAY: He has done them --

MR. FELDMAN: -- which have been verified in the field.

MR. CALLAWAY: He has shown one example of a verification, and it is a lousy fit to begin with.

MR. FELDMAN: Mr. Callaway, let me try it another way, because I don't think we are going to get very far this way. Assume with me for a second that Dr. Pritchard's Case IV is an accurate picture of what will happen with the kind of discharge, the kind of velocity, he assumes in his paper. Just make an assumption for a minute.

MR. CALLAWAY: You are asking for a lot.

MR. FELDMAN: Pardon?

MR. CALLAWAY: You are asking for a lot. I will do it.

MR. FELDMAN: Okay. If we make that assumption, is the last phrase in Conclusion No. 3 still accurate?

MR. CALLAWAY: Pritchard's Conclusion No. 3? I don't think it is particularly difficult to envision the warming of a large portion of the beach and certain adjacent waters. If you mean if his model works well, that is something else again. But I don't think it does in this kind of case. It doesn't make any sense. But if his model works, we could have another model that works twice as good -- ten times as much of the area -- so what is to be gained by that?

MR. FELDMAN: If his model works, then, the statement in Conclusion 3 that physical warming of a large proportion of the beach water zone will occur is inaccurate, is it not?

MR. CALLAWAY: If his model applies, right, sure.

MR. FELDMAN: Okay, then, therefore, would you agree with me that Dr. Pritchard's -- the clarifying statement issued Monday should have withdrawn that part of Conclusion 3 as well as whatever else it purports to withdraw?

MR. CALLAWAY: I don't think we had Dr. Pritchard's Model IV at that time. How could we do that since we didn't have it?

MR. FELDMAN: Isn't it only since you have initially learned about that that you think it is useful to withdraw the third conclusion?

MR. CALLAWAY: I meant no such thing.

MR. FELDMAN: Let me go back just a little bit, Mr. Callaway. Isn't the major difference between Dr. Pritchard's analysis of cooling and the general analysis of cooling which is in the "white paper" the fact that the "white paper" assumed no surface loss, and that is it?

MR. CALLAWAY: I don't think that -- say that again.

MR. FELDMAN: Isn't the major difference between Dr. Pritchard'[illegible]lysis of the behavior of heat that is put in the lake and the "white paper"'s analysis the fact that the "white paper" simply assumed that there would be no loss of heat from the surface?

MR. CALLAWAY: I don't think the "white paper" assumed that at all, that there be no loss. I don't see where you get that.

MR. FELDMAN: Well, you assumed that the bulk of the heat would stay in the lake, did you not?

MR. CALLAWAY: At the outfall, all of the heat is going to go into the lake. The plume is going to come to some sort of configuration by the loss to the atmosphere.

That is what I said.

MR. FELDMAN: Okay. And withdrawing those parts of Section 2C, which we have discussed for the last half hour or so, you were withdrawing those parts that went beyond that and implied that it is never lost to the atmosphere, did you not?

MR. CALLAWAY: I didn't imply -- I implied no such thing.

MR. FELDMAN: The "white paper" --

MR. CALLAWAY: Even if Dr. Benedict's model assumes no heat loss to the atmosphere you can find atmospheric conditions when that will occur. I don't say it is going to occur forever, but there are times when there is no surface heat exchange.

MR. FELDMAN: The rate of radiation from the water may for very short periods of time drop to substantially zero.

MR. CALLAWAY: That is right, and you might get a very good agreement between Benedict's model and one that accounts for cooling. There would be very little difference.

MR. STEIN: Would you repeat that? Between Benedict's model and --

MR. CALLAWAY: Yes, between Benedict's model which, in this case, didn't account for surface cooling and between the field study wherein you might have surface cooling occurring there may be pretty good agreement.

MR. FELDMAN: Do you ever expect to see a day on which there is no longwave radiation from a body of water back into the air?

MR. CALLAWAY: No, sir.

MR. FELDMAN: No?

MR. CALLAWAY: You are always going to have back radiation.

MR. FELDMAN: And, therefore, when Dr. Benedict assumed there would be no longwave radiation to the air, was he making an assumption which would be virtually impossible?

MR. CALLAWAY: I think you are putting some assumptions on Dr. Benedict's paper that you had best discuss with him.

MR. FELDMAN: Well, you said a few moments ago that under some conditions for some short periods of time a field study might be able to find a plume which behaves the way Dr. Benedict's does. I am just probing that.

MR. CALLAWAY: That just shows you how much use mathematical models are sometimes, right.

MR. FELDMAN: Mr. Callaway, if there is always longwave radiation from a body of water to the air, then is it ever permissible to assume there will be no loss of heat from the surface?

MR. CALLAWAY: Net loss, never.

MR. FELDMAN: When Benedict's study makes that assumption, it is making an assumption which is physically impossible, is it not?

MR. CALLAWAY: Yes, but I don't -- I lost track again.

MR. FELDMAN: I asked whether it wasn't true that Benedict's assumption of no loss of heat from the surface wasn't a physical impossibility.

MR. CALLAWAY: Yes, but this I want to bring out: You are making it sound -- and I don't want to be responsible for it -- you are making it sound like Dr. Benedict doesn't know what back radiation is and I wouldn't want to have that in the record. I am not trying to be obfuscatory towards you, but you are asking me some difficult questions.

MR. FELDMAN: Mr. Barber, I have just one more question.

MR. BARBER: Yes, sir.

MR. FELDMAN: Would you agree with me that insofar as the physics of the "white paper" is concerned and, therefore, the statements with respect to how much heat you get, the two major premises of the "white paper" are that heat which you put in the lake stays in the lake, and that heat which you put in the area near the shore stays in that area which is near the shore?

MR. BARBER: No, sir. I never interpreted anything that I read in several drafts of this report to mean that the heat stayed in the lake indefinitely. It doesn't have to, to do damage. As far as heat staying in the inshore zone, I feel sure that there are many, many times when there are significant currents that will take the shape of that shore. We see this in the wandering of plumes, as pointed out by Dr. Benedict and others here, so I don't mean to infer thatthe heat is necessarily all going to stay in the shore zone. It is going to respond to current, and the normal forces which create movement of water, such as density, temperature, wind and seiches, and so forth.

MR. FELDMAN: I am afraid when I ask a simple question this creates five or seven more problems, and it may be a little late to pursue them. I think while I might disagree with Mr. Barber, I think I understand now what his position is.

I am at the end, Mr. Stein.

MR. STEIN: Thank you very much.

Mr. Bane, did you want to --

MR. BANE: No, sir.

MR. STEIN: Do we have any other questions from the audience?

I am afraid as late as it is we are going to have to use this microphone. We have to give Mrs. Hall all of the help she needs.

MR. FETTEROLF: Mr. Stein, may I ask where Benedict's paper may be found? There is no citation on that.

MR. STEIN: Is there a citation to Benedict's paper?

MR. BARBER: Mr. Callaway -- did he leave?

MR. STEIN: Is there a citation to Benedict's paper, or can you supply this to Mr. Fetterolf?

MR. CALLAWAY: Do I have a copy?

MR. STEIN: No, a citation.

MR. FETTEROLF: I only want to know where I can get a hold of the paper. You do not give me any clues in the bibliography.

MR. CALLAWAY: Vanderbilt University.

MR. FETTEROLF: Does Dr. Benedict's paper compare actual plume measurements of the Campbell plume with his model?

MR. CALLAWAY: I am not sure at this stage. It has been a long time since I have seen it.

MR. STEIN: Yes.

MR. FELDMAN: If you will forgive me, I have one more question.

MR. STEIN: Oh, sure. When you said it was your last question, I was making book.

MR. FELDMAN: That is why I stopped even though I didn't get the answer I wanted, Mr. Stein.

You indicated the other day that the Department would make available the data which underlies various portions. I just wondered who we ought to write to.

MR. STEIN: Oh, I mentioned this before and let me make this clear to all. All of the data we have is public, at least in this field. Don't start questioning me on that. But you do know we have confidential data, for other reasons, but nothing involved in this.

Now, the data is available in our various offices. Your initial point of contact anyway is Mr. Mayo here, who is the Regional Director. Your contact will either be with the Fish and Wildlife Laboratory at Ann Arbor or with Mr. Yates Barber. Who do they get in touch with at Ann Arbor?

MR. BARBER: Well, let's mail it to the Director of the Laboratory there.

MR. STEIN: Either that or Mr. Yates Barber.

Now, in addition to that, Mr. Callaway is at our Pacific Northwest Laboratory in Corvallis and they have the data available. My suggestion to any of you is to deal directly with them and try to get the data. If you have any problem whatsoever call me, and I take collect calls. But what I am saying is -- not that I don't want the calls -- it is the long way around when you come to Washington. So I recommend that you try getting it directly from the source first, and we will cut out as much red tape as we can.

MR. FELDMAN: Thank you.

MR. STEIN: Mr. Petersen.

MR. PETERSEN: Mr. Chairman, I believe when we digressed into numerous witnesses, we were questioning Mr. Edsall, and he had not been released, so I would like to take up with Mr. Edsall where things got off into --

MR. STEIN: Did he come back?

MR. BARBER: He is right here.

MR. PETERSEN: I might observe that using Mr. Callaway's analogy, that if Benedict's paper didn't compare them with the Campbell plume this too must be witchcraft.

I think you are prepared on the question which I mentioned I was going to ask about this. I understand from what you had to say that all organisms drawn through condensers would be killed. Would you care to elaborate or explain further on that?

MR. EDSALL: In the next sentence I said something to the effect that the complete destruction of a year class of whitefishes could thus be accomplished during the first few months following hatching.

Basically, what I meant to say here was whitefishes. The statement probably also applies in another sense, too: plankton, including zooplankton and phytoplankton.

If you consider the number of phytoplankters passing through relative to the number of zooplankters and relative to the number of whitefishes, and if you assume that the majority of the phytoplankton plankters will be killed, which I believe that Morgan and Stross show on their paper, then we are still talking about a majority, nearly all of the organisms, numerically speaking.

MR. PETERSEN: Is your microphone working, sir? I found some difficulty in following and understanding what you had to say. But, as I understand it, you are referring to someone's paper and saying that that shows that all or nearly all of the plankton which may be drawn through a condenser will be killed.

MR. EDSALL: Phytoplankton, yes, sir.

MR. PETERSEN: Were you here to listen to Dr. Ayers' statement?

MR. EDSALL: No, sir, I heard about it secondhand.

MR. PETERSEN: It was the impression which I received from that, that the smaller organisms were not as grossly affected, but that of the larger organisms, 75 or 80 percent survived. Would you, on the basis of your studies, care to express agreement or disagreement with that?

MR. EDSALL: This paper isn't predicated on my studies. It is simply based on statements made by expert witnesses appearing for the Power Commission -- power interests in this.

MR. STEIN: Let's fix that thing. You mean the power interests?

MR. EDSALL: Yes, not Power Commission.

MR. STEIN: Off the record.

(Discussion off the record.)

MR. EDSALL: I had a point. Would you ask the question, please? I am sorry. I was distracted.

MR. PETERSEN: I thought you had given your answer. I asked: Can you, or do you care to agree or disagree with Dr. Ayers' testimony? I understood you to explain it not on the basis of your own experience and, as I recall, you answered you didn't have any of your own experience, but you referred to some paper which you said gave data to the contrary of Dr. Ayers' statement. That was given on behalf of the Federal Power Commission or the power interests or something of that nature.

MR. EDSALL: No, the paper is by Morgan and Stross and it is cited in the "white paper" in the literature cited. As I said, I didn't hear Dr. Ayers' paper, but from some of my fellow fish people I got a brief summary. As I understood, its conclusion was that a major portion of the zooplankters would be killed.

MR. PETERSEN: This being an informal affair somewhat, I don't object to your going ahead and explaining onwards and onwards, but I think the answer to my question was that really you couldn't agree or disagree on the basis of your own experience. Would that be a correct statement?

MR. EDSALL: Yes, I have no expertise in the field of phytoplankton or zooplankton. The important point that I was trying to make was that the destruction of the year class of whitefishes could be accomplished.

MR. PETERSEN: When whitefish larvae once fill their swim bladders -- I think this is the correct term -- are they no longer larvae or what is the stage when we say they are no longer larvae?

MR. EDSALL: Well, generally, when these fish hatch they are very small and transparent, and, in a sense, they do not resemble in miniature size the adult fish. Perhaps the best criterion for distinguishing between a larva and a nonlarva is the fact that the larva is transparent and nonlarva is not.

MR. PETERSEN: Are you aware of whitefish breeding areas in the vicinity of any present or projected thermal plumes from electric generating plants?

MR. EDSALL: I believe the paper says that historically all of the shallow inshore waters of Lake Michigan were whitefish spawning areas. Presently the stocks are down. There is a table in the report that shows they are down in abundance but that they are increasing.

MR. PETERSEN: Are you aware, as I suggested -- would you answer the question, please?

MR. EDSALL: I was getting to it in a roundabout way. Okay. My own experience is that there are spawning areas in the vicinity of Saugatuck, Michigan. My last full year on the research vessel, which was about 1963, was in that area, and whitefish were taken there, as I recall, during the spawning season when they were carrying eggs and apparently about to spawn. Circumstantial but --

MR. PETERSEN: I was going to ask, precisely where in that area? What is the area in which they laid their eggs as to location and depth of water from shore. But I take it from what you have said you only have evidence that there were pregnant -- heavily pregnant whitefish taken in the area.

MR. STEIN: They are not live bearers, are they?

MR. EDSALL: That is right. They have external fertilization, so they wouldn't be pregnant. The females were full of eggs that were about to be spawned. This would be within a mile of the mouth of the Kalamazoo River at Saugatuck, Michigan. The Kalamazoo River is shown on the map there pointing south of Grand Rapids.

MR. PETERSEN: Have you any reason to believe that any of the existing or projected thermal plumes would encompass that particular area one mile south of the Kalamazoo River?

MR. EDSALL: I am not sure where the projected installations would be in that area. Could you tell me that, and also the length of the plume, perhaps?

MR. PETERSEN: The Palisades projected plant is near South Haven and the Cook plant is, as I understand it, quite a distance to the south of that point, in any event, neither of which are near the point which you mentioned as to the Kalamazoo River.

MR. EDSALL: I would say in that event that the likelihood of a plume reaching Saugatuk from South Haven would probably be pretty remote. Most of our information on spawning is based -- and spawning areas -- is based upon the literature which deals with Lake Ontario and Lake Huron.

MR. PETERSEN: Are the areas in Lake Ontario and Lake Huron identical to those on the eastern shore of Lake Michigan?

MR. EDSALL: I would guess that they would probably be similar, yes. They certainly would not be identical.

MR. PETERSEN: That would be a guess?

MR. EDSALL: Right.

MR. PETERSEN: On what do you predicate your assumptions of damage to organisms going through the condensers? Is that mechanical damage or heat damage or both?

MR. EDSALL: I would say that probably was two out of three. The third one would be damage caused by sharp temperature rise, and the production of lethal air emboli within the tissues of the larvae -- body tissues.

MR. PETERSEN: Lethal -- once more for the benefit of the unscientific lawyer.

MR. EDSALL: Nonscientifically, "the bends."

MR. PETERSEN: Now, is your general theory of damage to whitefish, aside from being pumped through a plant, predicated upon the theory of no mixing outside of the beach zone?

MR. EDSALL: No, sir, I think I stated clearly that it wasn't.

MR. PETERSEN: Perhaps you did. I didn't get it.

Then, a general warming trend, which has been predicted in this theory is not a part of your thesis, but it is the -- but the general warming trend in a beach zone which is predicted by that theory has nothing to do with loss of whitefish insofar as you are concerned?

MR. EDSALL: I did not say that. What I was speaking of was loss of whitefish caused by the whitefish passing through cooling intakes and/or being entrained at the outfall. Other losses may occur, and Dr. Colby is perhaps a little bit more qualified to talk about this than I. But they involve loss or death of the eggs caused by the eggs coming in contact with slightly heated water during critical periods of their development.

MR. PETERSEN: As to the latter position, you are not speaking as an expert, is that correct?

MR. EDSALL: About the eggs?

MR. PETERSEN: About the eggs and the heat.

MR. EDSALL: Only that I have read some of his papers and I have, you know, watched him conduct his experiments.

MR. PETERSEN: Then, as I understand it, the only reference to the nonmixing beyond the thermal bar was the limitation on how often the beach zone water might be pumped through a plant or plants or what percentage of that water might be pumped through a plant or plants. I am not trying to catch you, I am just trying to understand you.

MR. EDSALL: I am not just sure exactly what you said. Could you say it another way, perhaps?

MR. PETERSEN: In your consideration of the possible damage to the whitefish population, the only way in which you utilized the theory of nonmixing across the thermal bar was to determine the chance of a given whitefish larva or juvenile being picked up through a plant.

MR. EDSALL: I think I know what you mean. Just let me restate something. Maybe it will make it a little more clear. What I said was that all information indicates that the larvae are abundant in the inshore waters -- I am sorry -- not inshore but beach zone waters, water shallower than 30 feet. By virtue of being in this area, they would be highly susceptible to being pumped through cooling systems. If there is exchange between beach zone water and nonbeach zone water -- water farther offshore -- as long as the larvae stay in the beach zone it doesn't make any difference whether we get any exchange or not.

MR. PETERSEN: Have you taken this idea -- made allowances for differences in intakes?

MR. EDSALL: Physical differences?

MR. PETERSEN: For example, the beach zone, as I think I understand it by arbitrary definition, is the 30-feet depth contour.

MR. EDSALL: By ecological definition, 30 feet, yes, sir.

MR. PETERSEN: What percent of the whitefish did you expect to find, then, between 20 and 30 feet in depth?

MR. EDSALL: I think it would probably depend upon meteorological conditions, and wave action, and this sort of thing -- turbulence in this zone. I suspect that if there were a lot of large waves crashing in on the beach that the larvae would move out to the area of non-extreme turbulence.

MR. PETERSEN: I am speaking of actually present in waters deeper than 20 feet and being below 20 feet in depth. Below meaning deeper than 20 feet.

MR. EDSALL: Below the surface?

MR. PETERSEN: More than 20 feet below the surface yet within the beach zone.

MR. EDSALL: I suspect that as they grow and approach the nonlarval stage that they would tend to move towards these deeper waters.

MR. PETERSEN: The question which -- now, taking that into account, would it make any difference in your thesis whether the intakes were at the shoreline or if it were 20 feet or 30 feet in depth? Have you considered it up to this point first?

MR. EDSALL: On any given day, I suspect that it probably would make a difference.

MR. PETERSEN: Have you, prior to my asking the question, considered this issue?

MR. EDSALL: Do you mean depth --

MR. PETERSEN: The depth of intakes in making your assumptions for the "white paper."

MR. EDSALL: We more or less assumed that the intakes would be shoreline intakes and I frankly haven't tried to envision whether a shoreline intake would be 6 inches of water or 16 feet of water.

MR. PETERSEN: Were you aware of the 3 plants, 2 presently in operation and 1 proposed, of Consumer Power Company on Lake Michigan's shoreline? Two of them have relatively deep water intakes and only 1 has what might be considered a shoreline intake.

MR. EDSALL: I am not really familiar with the intake structure of the powerplant. I am vaguely familiar with the intake structure of the Chicago municipal water plant system. I believe they are located in about 30 feet of water.

MR. PETERSEN: No further questions at this time. Thank you.

MR. STEIN: Thank you.

Are there any other questions here? If not, Mr. Yates, will you proceed.

I am beginning to get nostalgia. You know you haven't heard about a discussion like this for years. But about 20 years ago when we had this program, and we were working on primary treatment, and before the days we had computers, we also used to have scientific discussions, on sewage outfalls, of whitefish.

Mr. Barber.

MR. BARBER: Our next witness, we would like to ask Mr. Kenneth Roberts to read a brief statement. Dr. Graikoski, our botulism expert, was here on Monday, but at that time we had no questions, so we let him go home. Today we received a telephone message from him. This is the way we got this statement, so we will do our best to respond if you have questions, but I am going to ask Mr. Roberts to read it now.

MR. PETERSEN: If I may interject one moment, Mr. Chairman, it is 8:00 o'clock and I have no objection to going all night if it is the pleasure of the Board. But I think it would be helpful to those of us who are participating -- probably also to the reporter -- to take a break.

MR. STEIN: Well, I have been checking with the reporter. Would you rather go right through? If you take a break you are going to revive. Do you want to go through or not?

THE REPORTER: Let's take five minutes.

MR. STEIN: We will have a five-minute recess.

(Short recess.)

MR. STEIN: Let's reconvene.

Mr. Barber.

MR. PETERSEN: Mr. Chairman, in all that switch of witnesses, I lost two questions about evasive action and distribution.

MR. STEIN: Do you want to ask them now?

MR. PETERSEN: Yes.

MR. STEIN: Address them to whom?

MR. PETERSEN: Whoever Dr. Barber thinks is the right party.

MR. STEIN: Go right ahead.

MR. PETERSEN: One is: Just what evasive action can a whitefish larva take, and what action can a juvenile take? What is their swim speed, and on what do they base their theories of distribution of whitefish in Lake Michigan today?

MR. BARBER: Which of you two gentlemen back there can respond to this one best, please?

Dr. Colby will respond. I suspect he may have to ask for a repeat on the latter part of that question.

MR. STEIN: Why don't you try answering it and see how much you can cover. Go ahead, Dr. Colby. Did you hear the question?

DR. COLBY: No.

MR. STEIN: We will try one at a time.

MR. PETERSEN: What evasive action can a whitefish larva take?

DR. COLBY: Whitefish larvae are semi-planktonic in the sense that they do move with the current but they can swim. For instance, they can swim, and they are not totally dependent on the current. So they can swim away, but they are drifting as they swim. Do you understand what I mean?

MR. PETERSEN: Yes, I think I do.

DR. COLBY: Their swimming speed is 2 to 3 centimeters per second from the literature, if that will help you.

MR. PETERSEN: Now, the same question for the whitefish juvenile -- I think juvenile is the term you used.

DR. COLBY: Larvae?

MR. PETERSEN: No, after it is a larva, after it climbs the swim ladder it is no longer a juvenile or is no longer a larva, it is something else, is it not?

DR. COLBY: Well, this is a nebulous thing, calling a fish from a larva to a juvenile. I am talking about sac fry larvae. This is before they absorb the yolk sac.

MR. PETERSEN: How long does that take?

DR. COLBY: That depends on the temperature and -- you would have to give me a temperature. It varies with temperature.

MR. PETERSEN: Well, let's say average in Lake Michigan waters. I am sorry, I forgot, you haven't done your research on Lake Michigan water.

Well, Lake Ontario waters, was it?

DR. COLBY: No, it doesn't make any difference if it is Lake Michigan or Lake Ontario waters, it depends on the water temperature when they hatch.

MR. PETERSEN: I am trying to get -- if I explain this perhaps you can answer it better. I am trying to get a feel for how long the whitefish larvae are in relatively vulnerable position. I take it you are saying, with the yolk sac attached, during this period of hatching, which as I understand it goes from somewhere in April through May, from the testimony I heard here today --

DR. COLBY: Just a second, Tom, is it about three weeks to a month before the yolk sac is absorbed in the lake? I would have to check the record, but I would say three weeks at least.

MR. PETERSEN: When is the predominant hatch in Lake Michigan, do you know?

DR. COLBY: No, I don't.

MR. PETERSEN: About what time?

DR. COLBY: In April and May -- early May. The University -- I would have to call on the University of Wisconsin studies conducted by Walter Hogman. He has studied fish in the northern Green Bay area.

MR. PETERSEN: He wasn't the one who made the whitefish conclusions for the whitefish paper, was he?

MR. STEIN: That really is the "white paper," isn't it?

DR. COLBY: No, he isn't.

MR. PETERSEN: What is the sustained swim speed and darting speed for the juveniles?

DR. COLBY: I don't know.

MR. PETERSEN: Upon what does your Department or I should say the authors of the paper base their theories of distribution of whitefish at present in Lake Michgian?

DR. COLBY: We base it on studies by Walter Hogman. He is looking at them in Lake Michigan.

If there are whitefish in the Saugatuck area and they are reproducing there, then there are larvae there, but we have not made a survey of the spawning grounds on the distribution of whitefish or cisco larva in Lake Michigan, and I am making -- we are assuming -- we are making an assumption here. It is our opinion, from studies on Lake Ontario and Lake Huron, that they occupy the same areas in Lake Michigan -- the same type of areas as they do in the other Great Lakes, and that is what I am basing it on.

MR. PETERSEN: Is this the same kind of assumption that one of your colleagues called witchcraft a little while ago, or is this on a different basis? I am asking because I am not just sure when mathematical models and when projections of data are in this regard.

DR. COLBY: No, I don't believe this is witchcraft. This is my opinion.

MR. PETERSEN: No further questions. Thank you.

MR. STEIN: Are there --

MR. FETTEROLF: Dr. Colby, it was mentioned by Tom Edsall that larvae fish would die of air emboli. Has this been observed as the cause of death?

DR. COLBY: Yes, from laboratory studies.

MR. FETTEROLF: But not in heated plumes or not in plumes?

DR. COLBY: No, not to my knowledge.

MR. STEIN: Any further comments?

Let me ask you one question, Dr. Colby, and this is meant to really clear things up. I am somewhat familiar, against my will I must admit, with mathematical models. But would you consider studies which have been done in the field, say, in other Great Lakes, and then you extrapolate those field results to conditions which you must expect in Lake Michigan to be a mathematical model approach to things?

MR. PETERSEN: Mr. Stein, may the record show a very significant pause.

DR. COLBY: I don't believe I can answer that.

MR. STEIN: All right.

Are there any other questions or comments? If not, thank you.

Mr. Barber:

MR. BARBER: At this time, we will ask Mr. Roberts to read the statement on botulism.

STATEMENT OF KENNETH R. ROBERTS, RESOURCE MANAGEMENT OFFICER, BUREAU OF COMMERCIAL FISHERIES, ARLINGTON, VIRGINIA

MR. ROBERTS: My name is Kenneth R. Roberts. I am presently Resource Management Officer with the Bureau of Commercial Fisheries, Arlington, Virginia. I have a Bachelor of Science degree in fishery biology from Michigan

State University, my Master's degree is in fishery science from Michigan State University and I have 10 years of experience as a practicing fishery biologist.

It has been indicated that we would have a statement from Dr. Graikoski, who is a microbiologist in our Commercial Fisheries Laboratory, Ann Arbor. However, in reviewing the information which I got from him by telephone this morning, I find that there are a number of typographical errors that make it such that I hesitate to advance this as a statement on his part. I believe, for the purposes here, if it would be desirable, I would be glad to express his thoughts.

MR. STEIN: Why don't you go ahead and, with those reservations, put this in later. Anything you might give would be pertinent and add to the consideration of the conferees. (Dr. Graikoski's statement follows.)

MR. ROBERTS: All right, sir.

The question that was originally broached, I think, evolved around our mention on Page 74 of the "white paper" about morality of water birds, and in this we referred to multiplication of bacteria being encouraged by increasing summer lake temperatures.

One organism which is of concern is Clostridium botulinum type E, which is a bacteria, which is found in fish-eating birds on Lake Michigan and have caused human

ADDRESS ONLY THE DIRECTOR,
BUREAU OF SPORT FISHERIES
AND WILDLIFE

March 3, 1849

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
WASHINGTON, D.C. 20240

JAN 18 1971

Mr. Murray Stein
Assistant Commissioner -
Enforcement and Standards Compliance
Environmental Protection Agency
Water Quality Office
Washington, D.C. 20242

Dear Mr. Stein:

During the evening testimony of September 30, 1970 at the Lake Michigan Pollution Enforcement Conference, the topic of waste thermal effects on Clostridium botulinum type E was discussed. The National Marine Fisheries Service (the Bureau of Commercial Fisheries) specialist on botulism, Dr. John T. Graikoski, had returned to Ann Arbor and was unable to testify at that session. Since then, Dr. Graikoski has prepared a brief statement, and for the benefit and clarification of the record we would like it included in the conference proceedings. A copy of the statement is enclosed.

Sincerely yours,

Paul E Thompson

Paul E. Thompson
Acting Assistant Director -
Research

Enclosure

Dr. John T. Graikoski
Microbiologist, National Marine Fisheries Service
Ann Arbor, Michigan

October 13, 1970

As a way of background, I have been studying botulism for the past 20 years, most recently Clostridium botulinum type E in the Great Lakes.

As a consequence of the botulism incident of 1963, due to type E, which focused the problem to the Great Lakes Region, our laboratory initiated a program of botulism research--one objective being to assess the degree of contamination by toxin producing anaerobes in the Great Lakes. In addition to these studies, attempts were made to locate possible reservoirs of the organisms and preformed toxin in the environment. Not only fish, but various other elements of the ecosystem were analyzed for the presence of the organisms and toxin.

The results of these studies have shown that type E is quite prevalent in the various samples examined; and, in many cases, the incidence was high. In addition, the incidence of the organisms was found to vary between the Great Lakes and even in areas of the same lake. For example, the incidence is high in Green Bay and around the mouth of certain rivers on Lake Michigan; whereas, in open lake waters and in Traverse Bay the incidence is low. The overall incidence has not changed significantly over the past several years we have studied the problem.

In part, the higher incidence of the organisms observed in certain areas can be related to the water temperatures. In areas where there is a high incidence of the organism, the water temperature increases in late spring and remains at this elevated temperature to early fall.

Growth and toxin formation by type E is a function of both temperature and time, provided adequate substrates are available. Therefore, water areas at elevated temperatures are conducive for the proliferation of the organisms. A detailed study of one area on Saginaw Bay during the summer months demonstrated the increase in incidence, as well as toxin appearance in fish as the summer progressed.

Clostridium botulinum type E is peculiar, in that it can grow at 4°C (39°F) - although slowly. Therefore, in reference to type E growth, attention must be given to the temperature range under consideration. At sub-optimal temperatures (4°-20°C), a slight increase in temperature can cause significant growth; whereas, in the optimal range (20°-30°C), a slight change in the ambient temperature will not reflect significant changes in growth.

Although consideration has been given to the incidence of *C. botulinum* type E in Lake Michigan, the incidence of other pathogenic bacteria has not been studied heretofore in these waters to any great extent.

mortalities. Although this organism readily grows at low temperatures it has optimum range of about 68 to 86 degrees Fahrenheit. Since it becomes most common in areas of high localized temperatures, any increase in temperature within this range will stimulate both multiplication of the organism and production of its toxin.

That is essentially our statement and text.

MR. STEIN: Are there any comments or questions? Yes, come on up.

MR. HIPKE: My name is Jack Hipke, with Wisconsin Power and Light.

As I understand, the Clostridium botulinum bacteria is anaerobic which means without air, I am sure you know, and, as such, being in plumes I would think that they would be of less magnitude than they would in any other type of circumstance. If they should be in this plume at the time, and with slightly increased temperatures, I would think that bacteria that are aerobic would take the place of this anaerobic type bacteria, so I was just wondering if you could comment as to the possibility of replacement of the botulinum bacteria by other bacteria and possibly elimination rather than growth.

MR. ROBERTS: Okay. First of all, I am not qualified to respond to a question on the mechanism of the botulinum proliferation in Lake Michigan, but I will forward to you what Dr. Graikoski did tell me this morning.

Dr. Graikoski has been studying botulinum for the past 20 years, and most recently he has been focusing his attention on the botulinum type E. This effort began as a result of the botulism incident of 1963 which was due to type E, and focused the problem on the Great Lakes region.

MR. STEIN: What was that, smoked fish?

MR. ROBERTS: Yes.

MR. STEIN: Right. Go ahead.

MR. ROBERTS: At that time, this area of research began. One objective was to determine the degree of contamination by toxin-producing anaerobes in the Great Lakes and in known possible reservoirs of the organisms and resultantly formed toxin in the environment. Not only whitefish but other various elements of the ecosystem were analyzed for the presence of the organisms.

The results of the studies have shown that type E is quite prevalent in the various samples that have been examined, and in some cases the incidence is quite high. The incidence of the organism has been found to vary between the Great Lakes and even in areas of the same lake. For example, the incidence is high in Green Bay and at the mouth of certain rivers on Lake Michigan. In Traverse Bay, the overall incidence has not changed significantly over the past several years.

In part, the higher temperature of the organisms observed in certain areas can be related to temperatures of the water, and in areas where we have shown a high incidence of the organism, the water temperature is high and usually becomes so early in the summer. Growth and toxic formation is a function of both time and temperature. Therefore, warmed areas are conducive to the proliferation of the organism. A detailed study of one area on Saginaw Bay shows this to be the case. The results of that study can be made available.

MR. STEIN: Are there any other comments or questions?

MR. PETERSEN: Thank you for your prolonged courtesy.

As I understand it, these comments are not yours but of another individual not present, and they are the results of your studies.

MR. ROBERTS: Yes.

MR. PETERSEN: Perhaps you can answer one or two questions. I won't propose to ask you full details on his studies other than to ask you: Do you know if studies were made in plume waters to ascertain the effect in plume waters?

MR. ROBERTS: I do not know that. I don't believe that they were.

MR. PETERSEN: Now, are these bacteria which multiply in the water itself, or do they multiply in the bodies of hosts, fish, or crustaceans, or something of that nature?

MR. ROBERTS: I am not qualified to answer that.

MR. PETERSEN: Thank you very much.

MR. ROBERTS: What I am saying is: I am not really qualified to discuss this mechanism with you.

MR. PETERSEN: What I am trying to ascertain is if we are trying to find out what happened to certain bacteria which happen to be present in the water and passe through the plume and are subject to the rapid warming and reasonably rapid cooling, and possible, therefore, deleterious effect on their reproductive mechanisms for a short period of time, or if we are talking about a mechanism which is free in a fish which itself is warmed by placing itself in the plume.

MR. STEIN: Do you want to answer that?

MR. ROBERTS: I was going to say, from this statement, we have said that the incidence in the surface waters is higher in some places than others, and we have indicated the temperature is a governing factor -- a limiting factor. When this was presented to Dr. Graikoski it was with the assumption that significant areas of inshore waters could be warmed artificially.

MR. PETERSEN: I haven't any answers now, and I will have to say it was my understanding that fish take their temperature from the surrounding environment of the water and, therefore, it wasn't clear from your statement as to what was meant. If you say it was in the water itself, fine. I can't ask you further questions because you aren't an expert in that particular field.

MR. ROBERTS: That is true.

MR. STEIN: As I understand the point that was made, it was that there was general relationship of a higher incidence of botulism in warmer waters than there was in colder waters. Just given the same waters, and presumably without drawing any relationship, anything that was warmed significantly, which would warm a large area or significant area of relatively shallower waters in Lake Michigan, might be said to plot conditions which would cause a faster growth of botulism. This is the way I understand. Now, I am not trying to argue about the validity of the statement or answer any questions. This is the way that I understand the thrust of the comments on this.

MR. PETERSEN: Thank you, and I was trying to determine whether there was a difference between just plain warmer water or the dynamics of a plume.

MR. STEIN: Correct.

MR. FETTEROLF: Mr. Stein, when I read the paragraph on mortality of water birds, the part about the Clostridium botulinum type E, I called a bacteriologist associated with the Michigan Department of Natural Resources at their Rose Lake Wildlife Station. I found that he disagreed with the statement of Dr. Graikoski. And I am not going to present any questions on this. But I think if the conferees are to attach an importance to this statement, then they should hear from other bacteriologists such as Dr. Lee mentioned yesterday, or other specialists in botulism that are available.

MR. STEIN: Any comments?

MR. PETERSEN: Mr. Chairman, a young lady has come in -- I don't know who she is -- she is a microbiologist and has had some experience in this field. Perhaps -- I don't know whether you would want to hear from her or not, but she --

MR. STEIN: Not now. I have got some time after midnight, but it won't be here. We appreciate it.

Are there any other statements or comments or questions? If not, thank you.

Mr. Barber.

MR. BARBER: Thank you, Mr. Chairman. We would be glad to file a clarification on this question of Botulism which has been raised. I am sorry we couldn't respond more positively. We had the man here Monday, but unfortunately he was not able to return today.

MR. STEIN: Well, we have had several of the experts who haven't been subject to questioning. I think in the informal proceeding we shouldn't discount the statement just because the man was not here, because if we extended that rule, there would be quite a few. Notably Dr. Pritchard --

MR. FETTEROLF: Yes, the reason for my questioning the statement is that the time of migration of birds on Lake Michigan -- loons and grebes -- this is in the fall when the temperatures have started dropping, and it is this time that the outbreaks of botulinum in water birds are most pronounced on Lake Michigan.

MR. STEIN: Are there any other comments or questions? If not, Mr. Barber, go ahead.

MR. BARBER: I would like, now, to introduce Dr. Charles Powers of the National Eutrophication Laboratory, Corvallis, Oregon, with the Federal Water Quality Administration.

STATEMENT OF CHARLES POWERS, NATIONAL EUTROPHICATION LABORATORY, FWQA, U. S. DEPARTMENT OF THE INTERIOR, CORVALLIS, OREGON

DR. POWERS: Mr. Chairman, my name is Charles Powers, and I am with the National Eutrophication Research Program of the Federal Water Quality Administration in Corvallis, Oregon.

By way of background, I have a Bachelor's degree in zoology from the University of North Carolina, and a Ph.D. degree from Cornell University in the field of limnology and oceanography. And prior to my association with the National Eutrophication Research Program, a little over two years ago I was with the University of Michigan, Great Lakes Research Division, and in that respect had the opportunity to carry out research on the Great Lakes.

What I have to say here is a brief statement, and it is in the nature of what I would like to think might be a clarification with respect to some of our thoughts in the relationship of eutrophication to thermal pollution.

I think there is a little disagreement, maybe confusion, or what-have-you, with respect to precisely what we mean by eutrophication. I think it has gotten to be a little bit of a household word and it means different things to different people. I think in the strictest sense, eutrophication refers to the increase in concentration of dissolved nutrients within the water of a lake. These would be such nutrients as nitrogen, phosphorus, and other things which are essential to the growth of algae and other plants. This in itself, then, is eutrophication, and then the things such as increased algal growth, which in an advanced case of eutrophication tends to run into the more undesirable nuisance species of algae -- this is one of the common symptoms of eutrophication, so that there are many symptoms which this state of being enriched with nutrients displays -- large concentrations of algae, possibly depletion of oxygen in the deep waters -- I am referring now to experience with small lakes, and so forth.

In lakes in which nutrient concentrations are low, the phytoplankton seems to be mostly composed of diatoms, and as nutrient levels increase, as they wash into the lake, from the watershed, or if they are put into sources of domestic and other types of pollution -- so as nutrient levels increase by whatever mechanisms they get in there, you find that algal growth known as the green algae and the blue-green algae tend to greatly increase in numbers in the lake.

C. Powers

In lakes where nutrient levels are high, such as in Lake Erie, for example, a condition is attained in which the first algae to appear in the spring are mostly diatoms, such as one finds in a lake where the nutrients are low, and these are eventually -- as the season progresses, these diatoms are replaced at least in terms of the dominant kinds present -- they will be replaced by the green algae. This doesn't mean to say that some diatoms aren't there, but there will be more greens than anything else. And as the season progresses and we get into the summer, those greens will in turn be succeeded by the blue-greens which will become dominant. The blue-greens are the biggest nuisance-type of algae. These are the ones which tend to form mats, and they decay later in the season and may give rise to noxious odors.

In lakes of low nutrient level, this progression, this succession, I should say, of forms through the season doesn't appear to occur, and in lakes of low nutrient levels the diatoms are the dominant algae the year round.

Now, two researchers at the University of Michigan, Dr. Schelske and Stoermer, have recently reported at a meeting of the American Society of Limnology and Oceanography that the plankton diatoms comprise less than 10 percent of the phytoplankton in samples from the southern part of Lake Michigan collected there in 1969. This is unusual since in previous years they had found that the dominant forms were diatoms. In 1969, they said less than 10 percent were diatoms. To quote them they stated in an abstract of their paper -- they say: "'The evidence compared with data from Lake Erie and Lake Superior suggests that acclerated eutrophication in Lake Michigan is rapidly approaching the point of a severe environmental change in which the diatom flora will be reduced or replaced by green and blue-green algae."

What data we have available -- and most of this, I think, are probably the data which were collected by the Public Health Service in the early to mid-60's -- and a lot of these data are reproduced in the "white paper" -- I believe that is where those data came from. But they have available data to indicate that levels of nutrients, and particularly phosphorus, are higher in the near shore waters of Lake Michigan than in the open lakes. I will not attempt to define here just what we mean by near shore and open lake. I am not really referring to a 30-foot depth or a 100-foot depth, but near shore in a rather loose fashion.

As Dr. Lee pointed out yesterday -- and he is quite right -- we are not sure at all of the extent of temperature effect in stimulating the appearance and growth of blue-green algae. We do have this inferential evidence that I cited a moment ago where, as the season progresses in lakes which have high nutrient levels, we do find that the blue-greens become dominant during the warmest part of the year. We are not sure that it is strictly a temperature effect, But many limnologists, and I would mention, such as Dr. Ruth Patrick of the Philadelphia Academy of Natural Science -- she has a good deal of experience in the studies of temperature effects on algae -- and I feel that she believes that the correlation between the occurrence of blue-greens and the warm summer temperatures is a demonstration of the cause-and-effect relationship. We could point to some things she has said which indicate she thinks this may be the case.

In addition, Dr. Stoermer has said in another paper Lake Michigan is near what he calls a breaking point where a change to a nuisance eutrophic form would be indicated. It would seem, then, that with respect to the warming up of the coastal waters of the lakes, one should exercise extreme care in introducing or reinforcing warm water or other environmental factors which might help in effecting or bringing about such an unwanted change.

C. Powers

The evidence which Dr. Ayers presented yesterday -- and he also cited Joseph Mihursky -- indicated that there is not any stimulation of algal growth through algal cells being passed through the condensers, and if anything there is a destruction of the diatoms and other phytoplankton which mitigate against a stimulation of algal growth. But I think we need not rely upon the algal cells actually passing through the plant. But rather, then, I think we should think in terms if there is a general inshore warming, such as has been debated here this afternoon, by effluents, then one might find a situation which, in conjunction with increased concentrations of nutrients occurring in the inshore waters, might result in a stimulated growth of bluegreen algae. If the waters were artificially warmed, the period during which the bluegreens would dominate might be extended.

That is what I have to say about that. Thank you.

I wanted also to point out that I have found two references in which Mr. Petersen might be interested. Are you here, sir?

You were discussing with Mr. Carr the thermal bar, and I have here a publication. I will show you this. There are two references in this publication dealing with studies of the thermal bar in Lake Michigan. One, the physical aspect of it; and another, some studies of the plankton. I think it was the phytoplankton and how they occurred on the two sides of the bar. So if you are interested in that --

Also, Mr. Currie, did you ask Mr. Carr something to the effect that was there an example of a study where an entire lake had been heated, and if this had any effect on the production It seemed to me you had a question something like that, and I had a little thing here that might help you.

MR. CURRIE: It wasn't about the entire lake, it was a question of whether there were any studies of comparable discharges to comparable waters -- comparable, that is, to those that we are discussing on Lake Michigan -- which would show adverse effects on algal populations.

DR. POWERS: Right, and I think the answer would be no to that. I believe that is what Mr. Carr said also. In here the only thing I have been able to find was this Polish lake -- three Polish lakes actually -- where they point out that the richest phytoplankton flora occurred in the warm lake.and also they said productivity rates of the algae were higher than this. But the evidence given here is certainly not conclusive and I would not cite this as conclusive evidence. What I have here is only a citation of a Polish work cited by an American author. He gives nothing on nutrient levels, and so forth, and so one would have to go to the original reference to really decide whether anything conclusive was there, I think.

Thank you.

MR. STEIN: Thank you, Mr. Powers.

Are there any questions?

MR. PETERSEN: Making the assumptions for water heating of inshore or beach waters which I don't think you and I care to debate, Dr. Powers, as I understand your testimony, the possibility of advanced eutrophication as shown by proliferation of bluegreens depends largely on the nutrients present and the area in which the bluegreen count was high or at least diatom count was so low was around the Gary-Chicago area as opposed to, let us say, the Muskegan area or the Grand Haven area of Lake Michigan.

DR. POWERS: Referring to the 1969 samples?

MR. PETERSEN: Yes.

DR. POWERS: I asked Dr. Stoermer about this and he indicated that he had felt that rather generally over the southern basin of the lake. This was as specific as he could be at the time, because he did not have the data But he said that formerly he had found them only in the Gary-Chicago region. In 1969, he had found the blue-greens

-- I don't mean in bloom concentrations but in quantities exceeding anything he had seen before, generally through the southern basin which would be say up as far as Muskegan, or something like this.

MR. PETERSEN: Do you have any data as to the relative availability of nutrients in the various areas, or is the availability uniform throughout in the southern basin?

DR. POWERS: I think probably the availability would be greater in the eastern side of the southern basin because it is there that the four largest tributaries of the southern basin enter the lake. This would be the Muskegan River, the Grand River, the Kalamazoo River, and the St. Joseph River. These are the four principal rivers, and then as one proceeds past Gary and Chicago there are no more rivers of any consequence entering the lake until you get to Milwaukee. On this basis and the fact that the Chicago sewage effluents are not put into the lake, but are diverted to the Illinois River, I would think that the eastern side of the southern basin might have a larger influence than the rest of the basin.

MR. PETERSEN: Is this on the basis of observation or just your general ideas of what probably would be --

DR. POWERS: I have seen data -- and I am sure

I could not quote any of it -- but I have seen data on nutrient levels for those rivers mentioned and they do run quite high in nitrogen, phosphorus, and other dissolved materials.

MR. PETERSEN: What I am trying to get at in part here is: Are you telling us, or I should say, are you telling the conferees that plant siting, as to eutrophication as shown by accumulations of blue-greens, is an important thing?

DR. POWERS: I don't know that there has been enough accumulation of blue-greens on that east side, for instance, to merit a statement like that. I think I would say that with respect to -- if we are talking about the east side of the southern basin versus the west, for instance, that this is the side of the lake on which one would be more likely to get the blue-green flora if this were heated to some degree, which the blue-greens found favorable. It might prolong -- it might make earlier in the year the time that they become abundant and it might prolong their bloom, and I say bloom because I have already stated I really agree with Dr. Lee, because we really cannot prove this.

MR. PETERSEN: No further questions.

MR. STEIN: Thank you very much, Dr. Powers.

I am sorry it was so late that we got to you that we didn't have a larger captive audience so you could have given them the primer lecture on eutrophication. Next time we will try to do better.

MR. HIPKE: Just more or less in accumulation of data in Lake Erie, for instance, the greatest accumulation of bluegreen algae is located in the center where there is no heat discharge from generating plants, and you stated that the eutrophication process is primarily due to nutrition. So I would say that if this was the case, wouldn't you think that it was primarily due to nutrition and also photosynthesis due to the sunlight? And so, if this is the case in the shallow waters on the shore, wouldn't you find the more concentrated the nutrients the higher the accumulation of algae, rather than the heat that is supplied to the area?

DR. POWERS: There is one thing you said -- you say, "...the greatest concentration of bluegreen algae is located in the center" of the lake, did you say?

MR. HIPKE: Lake Erie, right.

DR. POWERS: This I really wasn't aware of. This may be true.

MR. HIPKE: I have seen some rather large concentrations of these in the western basin, for instance, which is ---

DR. POWERS: By the center you mean the geographical center of the whole lake?

MR. HIPKE: Approximately, yes. There is algal matter there. I can't remember exactly what the size is, but it is definitely in the center of the lake where we don't have any generating plants.

DR. POWERS: I would say there might have been some, on one occasion, but I don't think it is necessarily there all of the time. The last time I was down there -- and that has been possibly four years -- there were no mats there at all, but I saw mats in the western basin of the lake. These mats also move around you know. They will move by the wind and this is sometimes why they seem to accumulate overnight, because we have had a bloom and then there will be a movement of these things with the winds.

MR. HIPKE: Well, since you do find a large accumulation during the summer months, and since the sun time is that much greater, wouldn't you think that it would probably be due to photosynthesis and not nutrients? I think the heat factor there doesn't really play a part in it.

DR. POWERS: The nutrients -- of course, we never seem to get this unless we get a lake in which the nutrients are high -- phosphorus, 150 micrograms per liter or more -- because photosynthesis is a process by which these things multiply themselves.

As I say, there does seem to be a temperature effect. I said that I thought it was a difficult thing to prove.

I had a point and I talked myself right out of it. I am sorry.

MR. HIPKE: Thank you.

DR. POWERS: I am sorry, sir, thank you.

MR. BARBER: Thank you, Dr. Powers. We would like to call next Mr. Richard Callaway. He advises me that I have been putting him with the wrong laboratory, so I am glad he called it to my attention. He is with the National Coastal Pollution Research Program at the Corvallis Laboratory of the Federal Water Quality Administration.

MR. CALLAWAY: My name is Richard J. Callaway. I am chief of the Physical Oceanography Branch, National Coastal Pollution Research Program.

I have a B.S. and M.S. in physical oceanography from the University of Washington and from Oregon State University, respectively. I have been an oceanographer for the Fish and Wildlife Service, Public Health Service, and Federal Water Quality Administration since 1956. I am a member of the AAAS, American Geophysical Union, American Society of Limnology and Oceanography,

R. Callaway

American Meteorological Society.

My present interests are in computer simulation through numerical methods in estuarine and coastal waters.

My comments are restricted to Dr. Pritchard's paper. I do not argue fundamentally with Dr. Pritchard's explanation that the lake is merely a temporary storer of heat; however, it should be borne in mind that Dr. Pritchard's approach seems to be a highly simplified model of the environment.

I know that Dr. Pritchard is well aware of this difficulty because he is also consultant to us at the Corvallis Laboratory of the National Coastal Pollution Research Program on the state of the art of mathematical modeling in estuaries and has devoted considerable portions of his effort to this aspect.

One of the difficulties in dealing with the output generated by someone else's mathematical models is devining what the model actually consists of. It is not sufficient to describe the model in words; the equations and the boundary conditions and assumptions must be clearly indicated. It would have been helpful if the accompanying mathematics had been presented as an appendix. Without a full treatment of the methods of solution, no real evaluation of his tables and figures is possible. This is referring to the paper yesterday. As one indication of the completeness of his model some investigators have recently found an hydraulic zone in addition to the three discussed by Dr. Pritchard. This additional zone consists of our internal hydraulic jump at the discontinuity layer which can result in submergence of the outfall. This report was developed by Drs. Koh and Fan of Tetra-Tech, Pasadena, California, and is in the process of being published.

In essence, Dr. Pritchard's report gives considerable information on the input and output data but virtually nothing on the black box in between. Personally I am quite satisfied with simply looking at a TV show without trying to figure out how the input signal is transformed into the TV image. I don't think this should be the case here with regard to Dr. Pritchard's output which in this case is in terms of areas, etc.

It was also indicated by Dr. Raney that model experiments were conducted by Pritchard at the C of E Vickburg station. These results should also be made available for this new design.

I have used many numerical models of estuaries and river systems and have found that it is sometimes quite easy to generate results that couldn't possibly occur in nature. This can be done either by making bad assumptions or running a program with a bug in it or using incorrect input data. In this regard it is also sometimes quite easy to obtain a suitable comparison of model and prototype results by gradually tuning the input coefficients to fit the data. Such results are useful but not always extrapolatable. So even though Dr. Pritchard maintains on Page 13 that he has made "... use of the most recent knowledge of momentary jet entrainment, etc. ..." it does not follow that models or our knowledge of the physics are all that well developed. I might add especially with the jet entrainment situation.

In summary, it would have been useful if additional runs had been made assuming shallower depths of the mixed layer, by presenting the analytical or numerical methods used in generating the isotherms and residence times, and by supplying the computer code.

It may well be that Dr. Pritchard's model is the most advanced of the many models that have been developed on this and related problems. Without an indication of the fine points, however, the results presented have to be taken simply on faith.

These additional questions should be asked:

1) What boundary conditions were used in the

model?

2) Is Case IV a verified model?

3) Is a steady-state approximation useful in Lake Michigan?

4) Wouldn't a three-dimensional model be more realistic so that the analysis should also be carried out in the vertical?

5) If the depth of mixing is determined by the Monin-Obukhov length why should the assumption of a constant mixed layer depth be accepted here?

6) At the high ejection speed of the model couldn't rather unexpected circulation patterns arise, including zones of erosion and deposition? Thus, the simplified isotherm configuration given might not have any resemblance to reality.

Additional questions will arise with the availability of the mathematical and hydraulic model results.

MR. STEIN: Thank you, Mr. Callaway. Any comments or questions?

MR. CURRIE: I have one.

Your reservations as to Dr. Pritchard's results, I take it, then, go not only to his isotherm but also to his estimates of residence time, is that right?

MR. CALLAWAY: Yes, sir.

MR. CURRIE: Thank you.

MR. STEIN: Are there any other comments or questions?

Thank you very much.

Mr. Callaway, let me ask you something on this. I believe the problem or possibly the differences with these mathematical models is similar to some of these 5-year projected plans. That is, in changing the assumptions, where you move on them, you may or may not get certain desired results, and we are in the hands of the model maker. Now, you can shift these back and forth, but we never know whether we are certain as to what we are saying.

MR. CALLAWAY: I don't like to criticize models because I build them, but I think they can be misused more easily than well used. Did I answer the question?

MR. STEIN: Yes, that is what that model from Bergdorf-Goodman told me.

Any questions? Thank you very much.

Mr. Barber?

MR. BARBER: Well, we are approaching the end, I think, of our presentation.

I would like to make some summary comments relative to the portion of the "white paper" dealing with physical and ecological effects. After I have completed my comments, I will turn the mike over to Dr. Bruce Tichenor, who will comment on the cooling-feasibility report.

I would like to bring some attention now to some of the aspects of Dr. Pritchard's paper, and I think they are applicable to some of the other papers that have been presented here the last 3 days. I think we have all been wonderfully impressed with the quality of the scientists that have been employed to represent the power industry. I am quite certain of the thorough scientific qualifications of many of them from their national reputations. They also write very carefully, which is a pretty good indicator as well.

What I am referring here to is that we take Dr. Pritchard's paper and analyze it. I don't think that he has really brought us very much evidence at all. As Mr. Callaway has pointed out, he has an unverified model, which he is promoting, the validity of which can well be debated by other, as I call them, model mechanics.

If I may, I will just refer you to Page 26 of Dr. Pritchard's paper. I think I can raise my questions better that way than any other way. You will note there under some final comments that he reports -- as did Dr. Raney -- that he has investigated the circumstances associated with all mass mortalities of aquatic organisms reported in the past 5 years as having been caused by thermal shock. He doesn't tell us whether there are a hundred or one. He doesn't tell us where they were. He does not describe any of the circumstances involving them. He doesn't say what was killed, or who, and how the determination was made as to what caused the death. I do not doubt that he has investigated all of these things probably in a scientific fashion, but I am compelled to believe that if there was a great deal of evidence that he would have offered us some of it.

He makes an assertion that these have been killed by being caught in the intakes and trapped, I believe, against screens. I am not reading this word for word. The mike gets in the way of my reading. But I don't know how he made this determination. He has no indication of having autopsied any of these fish or other things.

Now, I am very glad that he did indicate this death factor in the intakes, because the Fish and Wildlife Service has been recognizing this problem for many, many years and recommending to the various power companies and others who build big water intakes that these be modified and screened so as to provide protection to the organisms that are caught therein.

I think we might have to question what I consider a rather glib assumption, that we will just modify the intakes and take care of all of these problems. Perhaps we will take care of adult fish, but I am not aware of any existing technology that makes it possible to screen out the very smallest larval fish, fish eggs, and all of the plankton. All of these organisms make up the balanced biota of a large body of water anywhere, especially Lake Michigan.

I will call your attention to the fact that Dr. Ayers did identify yesterday that there is significant damage to plankton forms, which do go through these intakes. Dr. Pritchard states that, "On the basis of my experience and my calculations of heat exchange from the surface of Lake Michigan, I find that the discharge of condenser cooling water from the powerplants currently proposed for Lake Michigan will have no measurable effect on the overall lake temperature." He doesn't really elaborate on this. I think he would have us believe that if the jet entrainment method is used that there would be virtually no heat effect on the lake.

However, insofar as I am aware of the five fairly large to very large plants, now under construction or proposed, the concept of the jet intake or exhaust -- excuse me -- the jet discharge,in the sense proposed by Dr. Pritchard, has not until now been brought to our attention. This is true of all our studies of those plants which have reached the construction license stage.

Dr. Pritchard goes on to say, "I do find that even using the most conservative assumptions, the area of the thermal plume from a 1000 MWE nuclear power station having excess temperatures greater than 2 degrees Fahrenheit would be less than 100 acres, and would have a maximum linear dimension of less than 1500 yards."

I am not quite sure why we should just accept this. It strikes me that he is saying,"If you use Model IV as I have proposed" and, of course, as you know, we have questioned whether this is really valid -- "that this is what you will get." But I don't understand what he means by "the most conservative assumptions," since he has three models in that table -- or four, in fact. He does not refer to any, and it is only Model IV that he proposes that the plume is down to 100 acres.

Now, ladies and gentlemen, I would like to suggest that these points should be reviewed very carefully. I am not implying that this is not a good paper, but I am implying that we cannot agree with the conclusions.

There is no significant data here which would really tend to refute the case which we have made in the "white paper."

I believe that if you will look through all of the other papers presented by the biological consultants at this conference, you will find one thing that is fairly common to them -- they are extremely short in reflecting Lake Michigan field experience, although there are some studies which have been performed and there is some evidence presented.

I merely wish to caution care in reading and reaching conclusions based upon those papers. In comparison, I would point out that our "white paper" has summarized the bulk of the literature which we had on the lake and does present a reasonably well-documented case for why there will be damage to the ecology of Lake Michigan from these heat discharges.

MR. STEIN: Thank you, Mr. Barber.

Any comments from conferees? Any from the audience?

If not, thank you very much.

Mr. Tichenor, do I understand you want to say something or not?

DR. TICHENOR: Not really. If there are some questions that are to be asked, then, I will be glad to answer them.

MR. STEIN: There are no questions.

By the way, I want to thank you all for staying with us and the courtesy you have shown in staying with this procedure so long. I do think this exchange has been very useful, and we are going to have a really useful document. At least we are framing the issues. A good portion of the material was brought out late or as we went on into the evening. I do want to thank the attorneys who carried the ball for the power companies for asking these questions and bringing all these points out.

So, at this point, I cannot help but observe that we would have been much further ahead if, in addition to questioning the Government witnesses this closely, we had questioned that closely the witnesses put forth by the power companies on their papers. We may have been much closer together. I guess this is the way things go.

We will stand recessed until 9 o'clock tomorrow in this same room.

(Whereupon, the conference recessed at 9:02 p.m.)

- - -

☆ U. S. GOVERNMENT PRINTING OFFICE : 1971 O - 422-409 (Vol. 3)